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PETRALOGY.

A
TREATISE ON ROCKS,

BY J. PINKERTON.

VOL. I.

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PETRALOGY.

A TREATISE ON ROCKS.

◆

INTRODUCTION.

§ 1. *Illustrations of the present Arrangement.*

Division of natural history.

THE study of natural history has been divided by the most esteemed authors, and by the general voice, into three Kingdoms, the Animal, Vegetable, and Mineral. These have again been subdivided into Classes, Orders, Genera, Species, and Varieties. These terms may be considered as strictly proper with regard to animals and vegetables; but as their common meaning implies a vital or animated principle, their application to the mineral kingdom, to which they have passed rather by habitual use than after a due examination, has become dubious; and has given rise to many variations and contradictions, and not a little obscurity. It is confessed that human systems have but a very remote connexion with the great operations of Nature, and are to be regarded as mere artificial memories: hence in mineralogy some eminent writers entirely reject Genera; while others, with Daubenton, say that there are no Species; and Dolomieu has in vain exhausted his acuteness and science to prove that real Species exist in this department. With all his metaphysical prolixity he has no disciples in this doctrine; and the idea of a Species remains dark, even to the most enlightened minds, because it is false and unnatural, as in the other branches of natural history a Species produces a similar progeny.

Some terms inapplicable.

Other objections.

Thus some writers have been contented to divide minerals into Classes, Orders, and Genera; while others, instead of the last, have only Species. Some have Varieties; and Werner, with a truly German want of taste, has added Sub-species and Sub-varieties; while, as the terms are merely arbitrary, he might have chosen far more classical words to express his distinctions.

The cause of this embarrassment, as has often happened in the progress of science, is owing to the pursuit of a routine, of a form, which has become antiquated; while the discoveries being wholly new, a new phraseology was indispensable. Thus in natural history Linnæus having established the received classification in botany and zoology, the same terms were introduced into mineralogy, without the simple reflection that the subjects were wholly distinct: for the terms, indicating animal and vegetable life, could not without manifest absurdity be applied to dead and inert matter. The consequence was, that as the terms conveyed no idea they were used indifferently, and what was *Class* with one author became Order with another; while the Genus of a third, as has been already mentioned, became the *Species* of a fourth: and a few of deeper sagacity began at last to doubt the propriety of one or other of these appellations.

In fact the terms class, order, genus, and species, convey real and vivid ideas of life. We say a class or an order of men, a genus or species of animals, with complete perspicuity and propriety. Nor is the transition to plants in the least violent, as the word species in particular may be here used with some classical authority. But when applied to minerals they become wholly arbitrary, and convey none of these substantial ideas which belong to real knowledge, and which the mind grasps, so to speak, as solid and tangible: for as the characteristics are here of a totally different kind from those of animal or vegetable life, they should be distinguished by new and appropriate appellations. As we shall never describe an animal from its texture, fracture, or other distinctions of minerals, so it is equally absurd to describe these by attributes which are peculiar to living substances. The terms become wholly useless if they do not serve to distinguish and discriminate; and numerals, chemical marks, or any other arbitrary symbols, would serve the purpose equally well.

The impropriety of the present phraseology is often admitted, while it is considered as bold and adventurous to hazard a new series of appellations; but in literature, as in war, he who shrinks from the path of danger will never attain the wreath of praise.

New system.

In an attempt to establish a new nomenclature of arrangement, the first requisite is, that it be conformable to the *simplicity* and harmony of nature; and that it be free from *affectation*, as even the novelty itself is apt to displease. For this purpose it is necessary to revert to first principles, and if possible to establish the edifice upon foundations universally admitted. Natural history, as already mentioned, has been well and popularly divided into three Kingdoms, the Animal, the Vegetable, and the Mineral. In the two former the kingdom consists of living subjects, who of course may be well considered as divided into Classes, Orders, Genera, and Species; but in the Mineral Kingdom the territory alone constitutes the subject of discussion. It must therefore be received as a fundamental truth or axiom, that the mineral kingdom, being wholly inert, cannot admit distinctions which belong to vital energy; and that an identity of appellations cannot therefore be allowed, either in a grammatical or philosophical view. But the very term Mineral Kingdom may of itself lead to a new and more proper nomenclature: for as a kingdom may be regarded as either vivified with animal and vegetable life, or as an inert tract of country, with certain geographical, chorographical, and topographical divisions; so the latter point of view can alone apply to mineralogy, while the former belongs to zoology and botany.

This simple induction will, it is hoped, lead of itself to easy and natural, though new denominations. For what is more usual than the division of a kingdom into provinces, districts, domains, &c.? while, as it would not only be pedantic, but inadequate to the subject, to carry this species of metaphor too far, some lesser divisions must be borrowed from the nature of the objects, as they present themselves to the observer.

Grand provinces.

I would propose, therefore, in the present advanced state of the science, that the mineral kingdom be considered as divided into three provinces: 1. PETRALOGY, or the knowledge of rocks, or stones which occur in large masses. 2. LITHOLOGY, the knowledge of gems and small stones. 3. METALLOGY, or the knowledge of metals. Each of these branches is even at present so important, and offers such numerous topics of disquisition and research, that in the course of no long period a professor of each will appear in universities; and each might occupy the sole pursuit of an author who is zealous to make discoveries, or to compose complete and classical works. One of the chief causes of the slow progress of the science is, that it is too wide for one mind; and as zoology has been divided into ornithology, ichthyology, entomology, &c. so mineralogy, to be duly studied, should have grand subdivisions.

Domains.

These provinces may again be viewed as divided into DOMAINS, corresponding with the Orders of some writers and the Genera of others, as the Provinces supply what are called Classes. This term DOMAIN is preferred to District, &c. as it not only implies a subdivision of a province, but, in another acceptation, a ruling or preponderating power, strictly applicable in mineralogy, where it is often the preponderance, and not the universality, which imparts the denomination. Thus in the siliceous, calcareous, and other domains, it is only understood that the denominating portion preponderates, as few or no rocks are pure, and unmixed with other substances.

Substantial.

Petralogy, a province of mineralogy, may therefore be regarded as divided into Twelve Domains; of which the first six, being distinguished by the substances themselves, may be called SUBSTANTIAL: while the remaining six, being distinguished by circumstances or accidences of various kinds, may be called CIRCUMSTANTIAL, or ACCIDENTIAL; but this last division is of little moment.

The first six domains of Petralogy comprise, 1. The Siderous Rocks, or those in which iron predominates, not in the comparative quantity when analysed, but in the quality and essential difference which it imparts. 2. The Siliceous, denominated as usual from the quantity of silex. 3. The Argillaceous. 4. The Magnesian: these two are again denominated from *predominance*. 5. The Calcareous. 6. The Carbonaceous.

Accidential.

The remaining six domains, derived from circumstances or accidences, are, 7. The Composite, or Aggregated Rocks, as calcareous spar with schorl, quartz, and garnets, felspar and siderite or hornblende, &c. This domain has often been confounded with the granites, however alien from that description. 8. The Diamictonic, or rocks in which the substances are so completely mingled, that it is difficult, even upon an analysis, to pronounce which preponderates. 9. The Anomalous, or those which contradict the common order of nature, and present unexpected and unusual combinations. Some of these domains, though they afford few objects at present, may, in the progress of the science, be greatly enriched and enlarged; and the utility of such divisions will be more perceptible as the study advances towards perfection, the greatest obscurity at present arising from the want of necessary subdivisions.

The remaining three domains are generally admitted in geological works, namely, 10. The Transilient Rocks, an interesting series, in which one substance gradually passes into another, as granite into porphyry, trap into wacken, and the like. 11. The Decomposed Rocks, which gradually decay into sand, clay, or productive soil. 12. The Volcanic, which require no other description.

Modes.

Having thus established the Domains, or Great Divisions, of Petralogy, the smaller distinctions can be derived only from the objects themselves, as we now arrive at what are by most mineralogic authors denominated *Species*, though in their arbitrary and unnatural systems, as Dr. Townson has observed, the Genera and Species are often confounded. "Thus in the improved edition of Linnæus, the characters which constitute the *Species* in gypsum form *Genera* in the carbonate of lime; for the pulverulent, fibrous, spathous, and compact kinds of gypsum form but so many *Species*, whilst the pulverulent, fibrous, spathous, and compact kinds of carbonate of lime form so many different *Genera*."[*] Now these very appearances, which constitute the arbitrary Species and Genera of former authors, what would they be, in the eyes of a philosopher or grammarian, except different *modifications*, or *modalities*, of the same substance, and which by a shorter term may be denominated Modes? Hence the term MODE, which is universally applicable and unobjectionable, to distinguish such objects in mineralogy, is here admitted instead of Species[†].

To put the propriety of this new appellation to the test, examples may be produced of what are called Species by the most celebrated mineralogic writers. Wallerius, among the species of garnet, first mentions that of an undetermined figure, composed of granular particles; and his next species is of an undetermined figure, but laminar. What are these but different modifications, or modes, of the same stone? His ripe asbestus, consisting of fibres which may be separated, forms one species; while that of which the fibres cannot be separated constitutes another. What are these but different modifications of the same substance? In the last edition of Linnæus by Gmelin the term *modes (modi)* has been applied to various appearances of petrification: but what are sometimes called Genera, and sometimes Species (as already observed from Dr. Townson), are, in strict language, mere modifications of matter. If we pass to one of the most exact of the French mineralogists, we shall find the sapphire arranged as the tenth species of the siliceous, and the topaz as the eleventh; while in fact they merely differ in colour. In the magnesian division, what are bole, fullers' earth, &c. but different modifications of the same mixtures? Mr. Kirwan presents no exact arrangement, but uses Classes, Families, and Branches, in such a manner as greatly to perplex the reader: but all his species and families are mere modifications, and the simple division into modes would convey a far clearer idea *.

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[*] Philosophy of Mineralogy, p. 173.

[†] Εἶδος implies *modus*, as well as *species*.

The term Mode is therefore here adopted instead of what are called Genera by some writers, and Species by others; this uncertainty, of itself, having demonstrated that there are neither Genera nor Species in mineralogy.

Chemical.

But as it is now universally allowed by all mineralogists, however different their systems, that the whole science rests upon chemistry alone, and that no certainty can be found except by chemical analysis, the word Mode, as finally admitted into the present system, must be chiefly understood to refer to the CHEMICAL MODE OF COMBINATION, upon which the nature of the substances, as is now allowed by the greatest chemists, is yet more dependent, than even upon the ingredients combined. It is the MODE OF COMBINATION which distinguishes a diamond from carbon, and a sapphire from argil combined with a little iron: the essence of a mineral consisting not only in the constituent earths, but in the peculiar way in which the mixture is *modified;* and this modal influence also prevails in many artificial mixtures and compounds †. In short, the pretended species of former authors are merely different MODES OF COMBINATION.

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* Dr. Thomson, in his valuable Chemistry, has preferred the *families* of Werner, and discarded *the old genera;* iv. 247. Mr. Jameson tells us that there is in fact only ONE species in mineralogy, namely the globe; but even this may be doubted till it shall have produced another, at least as round and as wicked.

† This may be exemplified from the Arragon spar, in which the ingredients are the same as in calcareous spar, yet it differs in many properties, not from composition but from modification, the gangart of red clay or gypsum probably imparting a tincture of iron.

Structures. This, the most important part of the arrangement, being thus borrowed from chemistry, which, like a guardian angel, should always hover round and direct the labours of mineralogy; the other subdivisions only require a characteristic clearness to assist the memory (the chief object in any system of natural history), and an appropriation to the subject, so as to satisfy the judgement and imagination. From the earliest productions of Linnæus to the present time, the word STRUCTURE has been applied, with classical propriety, to denote a most striking and characteristic distinction between mineral substances, whether on a great or on a small scale. Linnæus has observed that there are only three great roads which can conduct the curious traveller through the mineral kingdom; that of Physics, or Natural Philosophy, which treats of the obscure generation of stones; that of Natural History, which examines their evident structures; and that of Chemistry, which considers their analyses *. A term thus strictly appropriated, and, as it were, consecrated to the science, has therefore been selected for the next characteristic subdivision.

Aspects. But as Werner and his disciples not only admit the various earths as so many Genera; and their Modes, or the modifications of the mixtures, and even colours, as so many Species; but also what are, with great penury and uncouthness of language, styled *Sub-species*, with still smaller divisions of *Varieties* and *Sub-varieties;* so there remains a necessity for more minute discriminations in this new arrangement. In his excellent and elaborate system of chemistry Dr. Thomson seems to have hit upon the just and natural term, when he uses the word ASPECT as a chief characteristic. "The particular characters, says he, are the following: 1. Aspect of the surface; 2. Aspect of the fracture; 3. Aspect of the distinct concretions; 4. General aspect, &c." As therefore the most important object in the study of minerals is to distinguish them by their external characters, and especially by those apparent to the eye, the aspect becomes of such radical importance that it may with the greatest propriety be *admitted* into the distinctive nomenclature. The verb *aspecto* signifies to view with great attention or earnestness, and affords a hint to the student that these subdivisions called aspects require strict attention and discrimination. Thus, while the Mode chiefly expresses the difference of chemical composition, &c. and the Structure the grand characteristic, the Aspect refers to more minute features. The term *variety* is unobjectionable, as it is equally applicable to objects of animated or inert matter; and *diversity* may be used to imply a still greater difference than the *variety* presents. A very faint shade of difference might, if necessary, be called a *lineament*.

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* "Via triplex tantum per Regnum Lapideum curiosos ducit: Physica quæ descendit per Lapidum obscuras *Geneses*. Naturalis quæ excurrit per Lapidum apricas *Structuras*. Chemica quæ adscendit per Lapidum destructivas *Analyses*." Linn. Min. à Gmelin, p. 14.

In the edition of his System, Holmiæ 1768, Linnæus has the following among the external characters: "The Structure, foliated, fissile, convergent, in fragments." Werner says limestone is of a simple structure. Dr. Thomson, in his valuable Chemistry, says that gneiss differs in its structure from granite; and that the structure of mica slate is thinly schistose. It is chiefly judged by the fracture; and is as applicable to small specimens, if well chosen, as to the rocks themselves: it may be earthy, compact, columnar, large-grained, &c. &c. In classical Latin *structura* is not only applied to the largest edifices, but in very minute senses, as *structura versuum*, *structura verborum*.

Varieties, &c.

Having thus briefly explained the present system, the result of the reflections and meditations of many years (for it is well known that simplicity in a plan, or a machine, as it is the most perfect quality, so it is the last which is discovered), it may not be unnecessary to illustrate its necessity and utility by some further observations.

The embarrassments of the former systems cannot be more forcibly evinced than by the following discussion by Werner, in his important work on the External Characters of Minerals.

Werner's difficulties.

"I shall here add some remarks upon the division or natural order of bodies in general, as well for example, as explanation of this paragraph. When we wish to arrange a system; or, which is the same thing, when we wish to determine the natural order of bodies, we must first find a principle on which to ground that determination. But this principle should be taken from the nature of the bodies, as being the consequence of it; and since it is by that we determine in what degree these bodies are similar or unlike, it should show equally the principle of their difference. We perceive in these bodies certain resemblances which are the foundation of their differences, and as these several resemblances are more or less allied or varied, so it is with the bodies which produce them; this then is the only principle on which we can determine the class or order of these natural bodies. It remains now to show where relations are found in natural bodies; but here we find a difference between them, for they are divided into two principal species, these relations in one consisting in the conformation, and those of the other in the composition. The first comprising animals and vegetables, as the second embraces meteors and the mineral kingdom. It is true that, as being natural bodies, they are at the same time aggregated and composed; but the first are formed of parts differing one from another, and which we call *organs*, which constitute their relations; the last, on the contrary, are simple, or formed of similar parts, and consequently can have no relationship in their aggregation. Now, as they nevertheless really differ, that is to say they have different characters, we must endeavour to recover them in some manner; and, as I have already said, this can be only by their composition. As a proof of which, when I have divided into as small parts as possible, a substance of one of the first two kingdoms, for example a plant, I cannot affirm that each separate part is the same plant; because not any of these parts have the same relationship as in their state of aggregation, that is to say in their entire plant, and that it is this total which forms this or that plant. It is then in this reunion that we must show the character of this plant, since it is destroyed by the division. On the contrary, I can divide any mineral whatever as I will; the smallest particle that can be obtained by mechanical instruments, will always be the same mineral; for each particle, be it ever so small, preserves the same properties as would the whole in their collective state. These qualities consequently are not confined to the aggregate, since they do not cease with it. But if I destroy the composition of a mineral, that is to say, if I reduce it to its constituent parts, then each separate constituent part is no longer the same mineral, because it has not the same properties as when in composition. When, for example, I decompose the glassy silver ore *(glaserz sproede)* in separating the silver, the sulphur, and the arsenic; or cinabar, in withdrawing separately the mercury and the sulphur; I cannot then say of these constituent parts, that they are still the mineral in the composition of which they formerly existed. Thus there is no doubt that the relations of minerals consist in their composition, since they cease with it.

" In the second place, the gradation of natural bodies into one another (which is the most infallible sign of the natural order), shows us that the different relations of the bodies of the two former kingdoms consist in their aggregated state, by means of which they pass as it were the one into the other; as likewise that the relations of bodies of the two latter kingdoms, that is to say, minerals and meteors, are in their composition, because it is only by reason of this composition that they pass the one into the other: as, for example, in the mineral kingdom, the glassy silver ore passes to another kind (the brittle); this to the red silver ore *(Rothgultig)*; and this again to the white silver ore *(Weissgultige)*; according as to the first is joined arsenic, to the second raw iron, and to the third copper. In fine, we have a sufficient number of examples of passages of the animal kingdom into the vegetable, and of the mineral kingdom into that of meteors; whereas, with regard to the passage of the animal and vegetable kingdoms into the mineral, we have no proof: and indeed, as we have before observed, that can never be, because in the first the natural order of relations follows their aggregation, while in the latter it follows their composition.

"But the following question may still be raised concerning the order and system of minerals: 'As it is certain that minerals, when their composition changes, are also changed in their exterior, cannot we in this exterior find characters to determine their natural order or sequence, as well as those that are taken from their affinities of composition?' Here is the answer: We can, it is true, discover the different relations of composition in minerals by their different external characters, when they are both determined beforehand; but we cannot discover the order of these conformities, because nature employs indifferently sometimes one character, sometimes another, to indicate the interior difference, that is to say, the composition; in the second place, because each exterior character sometimes arises from an essential difference, at other times only from an accidental variety. The systems of those who have inclined to arrange minerals by their external characters, may already furnish proof of the inconveniences of this method, because we there see minerals brought together which are essentially different; and that those of the same kind are separated by reason of some accidental variety. Botanists and Zoologists have this advantage, that in the objects of those sciences they find the conformities of bodies by their exterior; and that while they endeavour to class them, according to the aggregation of their external parts (or organs), they describe also their external characters, and in some measure accomplish these two objects at the same time. The labour of mineralogists is quite different; they must determine at once the composition of minerals by their appearances under chemical operations, or otherwise leave it to be determined by the chemists, and consequently class them accordingly. They ought, on the other hand, to seek after their exterior characters, in order to complete the description from them.

"I shall also remark, in the first place, that mineralogists hitherto seem to me to have been too much attached to the retention, in their systems, of the four gradual divisions of the logicians, into *classes, orders, genera,* and *species;* and that, to a certain degree, they thereby do violence to nature. I, nevertheless, believe that in this respect we may determine something certain; that is to say, how many degrees there are in the division of minerals according to their constituent parts: but as this is not the place to enlarge on this subject, I shall reserve it for another occasion, since, in regard to the subdivisions, it is always well to preserve those once introduced.

"I shall observe, in the second place, that mineralogists are little agreed, and are even undecided, with regard to what *they* call the *species:* if we would take this word in a determined sense, in general, all minerals that essentially differ from one another in the relations of their composition form different species; and all those that essentially assimilate in these relations, should be considered as forming one sole species. Moreover, all the separate pieces of one species are *individuals*[*], to which we substitute the word *species,* because it is impossible to have at the same time the entire species which comprises all the mineral individuals which may be found buried under the earth, or upon its surface. In short, all the minerals by which one species passes into another, and which accidentally differ in one or other of its characters, are *varieties.*"[†]

Species of logicians.

The division into Genus and Species seems, as Werner here justly observes, to have been first conceived by the writers on rhetoric and logic. The great Milton, in his Latin treatise on logic*, has discussed this subject, chiefly on the authority of Aristotle and Cicero: his examples are only accidentally from living beings; and he even appears embarrassed to distinguish between the species and individuals; for he argues that, as form is admitted by Aristotle as a discrimination of the species, and every man differs in form from another, so every man must form a distinct species. He adds, that the lawyers allow *man* to be a genus, while *individuals* constitute the species; but he observes, that Ovid divides the *genus* ANIMAL into *five species: Stars, Birds, Beasts, Fishes,* and *Men.* So Cicero divides *virtue* into four *species:* Prudence, Justice, Fortitude, and Temperance. The pedantry of this great poet is truly risible; but thus it was when logic was the art of talking nonsense according to a fixed method. Yet it is from logic, as Werner and the other German mineralogists allow, that the imaginary distinctions of genus and species were admitted into mineralogy!

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[*] This word is a further proof of the absurdity of the classification; for a plant or an animal may be an individual, but a mineral may always be divided *ad infinitum.*

[†] Werner, Traité des Caracteres Exterieurs des Fossiles, trad. de Madame Picardet, Paris, 1790, 8vo. p. 9—18.

The German terms used by Werner (see *Principes de Mineralogie,* par Berthout et Struve, Paris an 3,) are *Geschlechter* for Genus; *Gattungen* for Species; *Arten* for *Sub-species.* The first (see Schwan) means genus, species, race, may genders, nation. The second, sort, manner, species of animals. The third, sort, species, race, nature, complexion, air, manner, custom, fashion.

Dolomieu being sensible that the whole process depended upon ascertaining the *species,* which if once admitted, the *genera,* &c. would follow of course, has employed much metaphysical reasoning in his usual prolix, confused, and digressive style, to ascertain an imaginary species in mineralogy. He ought to have begun by informing his readers, that he was only discussing the word species, *as used in modern natural history,* where, in that of animated nature, it has become a useful distinction. But the ancient and classical senses may be learned from the commonest dictionaries†.

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* London, 1672, 12mo. cap. 27.

† As for example that of Ainsworth. "SPECIES, *ei.* f. (à SPECIO.) (1.) A form, figure, fashion, or shape. (2.) A sight, or object presented to the sight. (3.) A likeness, or representation. (4.) An outward show, or appearance. (5.) Colour or pretence. (6.) A vision or sight, a spectre. (7.) An image, picture, or statue. (8.) An example, a specimen or instance. (9.) The quality or nature of a thing. (10.) Also a particular sort, a kind of things under a general head. (11.) Sight or view. (12.) All kinds of spice, a drug. (13.) Corn or fruit. (14.) A piece of money. (15.) A garment, or apparel. (16.)

Classical meanings.

It is indeed not a little remarkable that, among the numerous senses in which the word species is used by the Roman classics, there is little appearance of its modern sense in natural history. Nay, even in the modern languages, all its derivations and collaterals may be equally said to be foreign to that acceptation; as for example in the English, *special, specially, specialty, specific, specifically, specificate, specification, specify, specimen, specious, speciously*. It therefore chiefly belongs, with the greater part of the Linnean language, to a modern latinity so barbarous, as even to confound genders and cases, and many others of the commonest rules of grammar.

But to return to its use in modern mineralogy. In his able criticism on Haüy's *Tableau Comparatif*, the last fruit of the researches of that eminent crystallogist, Lametherie has shown that the supposed species can be ascertained by no means but that of chemical analysis; and that the doctrine of the integrant molecule has been abandoned by Haüy himself*.

Any sort of meat. (17.) A controversy.—(1.) Species et figura humana, *Cic. pro T. Rosc.* 22. Specie lepidâ mulier, *Plaut. Rud.* 2, 4, 2. Promissa barba et capilli efferaverant speciem oris, *Liv.* 2, 23. (2.) Non tulit hanc speciem furiatâ mente Chorœbus, *Virg. En.* 2, 407. (3.) Speciem ac formam similem gerit ejus imago, *Lucr.* 4, 49. (4.) Moveri falsâ visione, et specie doloris, *Cic. Tusc.* 2, 18. Præter speciem alienæ fungendæ vicis suas opes firmavit, *Liv.* (5.) Ӿ Securitas specie blanda, reipsa repudianda, *Cic. de Amic.* 13. (6.) Non prius hostem destitit insequi, quam species barbaræ mulieris humanâ amplior, victorem tendere ultrà sermone Latino prohibuisset, *Suet. Claud.* 1. Sibi quoque eandem speciem aliquot jam noctibus observari retulit. *Id. ib.* 37. § Species Homeri, *Lucr.* 1, 125. (7.) Ex ære species vetus, *ap. Cic. Div.* 1, 12. Est aurigæ species Vertumnus, *Prop.* 4, 2, 35. (8.) Hanc speciem libertatis esse, si omnibus, quod quisque vellet, legibus experiri liceret. *Nep. Timol. sub fin.* (9.) *Liv.* 35, 49. (10.) Ӿ Cum genere idem sit, fit aliud, quod quâdam parte et specie differat, *Cic. de Inv.* 1, 27. Ӿ In universum, *Tac. Germ.* 5. (11.) Luna potest majus lumen convertere nobis. Ad speciem, *Luc.* 5, 704. (12.) Curabis ut specierum vis omne corpus inficiat, *Pall. Octob.* tit. 14. (13.) *Arcad.* (14.) *Litt. ex Macr.* (15.) *Capit.* (16.) *Lampr.* (17.) *Dig.*"

* L'analyse ne prouve que le fer chromatè est une espèce, que parce qu'elle y trouve constamment les mêmes principes. Donc il n'y a que l'analyse qui determine les espèces. Donc toute substance, cristallisée ou non, dont l'analyse

As it is therefore granted on all hands, that chemistry alone can decide what is called the species, and that it depends chiefly on the MODE OF COMBINATION, is it not more logical and philosophical to adopt the only term which can express its real nature?

It is clear that Haüy has abandoned his doctrine of species, in which he had followed Dolomieu, who assumed the *molecule integrante* of Delisle as the basis of a species*. Dolomieu closes his elaborate essay on the subject with the following strange definition of a species, in fact a mere *ens rationis* in mineralogy.

Dolomieu's species.

"The mineralogic species is a being distinct from all others by a particular constitution, and which receives from that constitution every thing which should characterise it. This being exists in the integrant molecule, is physically represented by the homogenous masses which have been submitted to the laws of regular aggregation, and it holds under its dependence all the beings which have a similar constitution, even when faults of conformation set them at a distance from the physical representation of the species, or when superfluities and contaminations make it wear a foreign livery." A very curious and original specimen of a definition!

Though Werner repeatedly allows that all mineralogical arrangements must depend upon chemistry, as they can only be formed on the quality, and quantity, and mode of combination of the constituent parts; yet, with a not illaudable predilection in favour of natural characters, he uses them chiefly to decide the species; while the species is in fact the most important and the most dependent upon chemical

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retire constamment les mêmes principes, est une espèce. Il n'est pas necessaire de savoir si elle a une molècule. Mais l'analyse seule est insuffisante, il faut encore avoir ègard aux caracteres exterieurs, et aux propriétés physiques; comme pour le spatte calcaire et l'arragonite, le ruthil et l'oisanite. *Journ. de Ph. Juillet*, 1809.

* See Tableau, p. ii. "J'ai préféré l'indication de *la forme primitive* a celle de *la molécule integrante*," &c.

aid[*]. Hence have arisen the chief errors in his system, ably exposed by Chenevix, who has shown that the different species of Werner are often vague and indeterminate; and the order of his arrangement not seldom capricious and imaginary, and far from being founded on his own principle of chemical composition. The calcareous spars are united under several *groups*, according to the acid which predominates. Those he has marked A, B, C, D, are truly German distinctions. Dr. Thomson has justly observed, that by his use of *groups* and *families*, Werner is struggling against his own system.

But the *mode* admitted in the place of the *species*, obviates these difficulties. It presents a real chief distinction between the species, that founded on chemical analysis, as it refers to the *mode of combination*, the ruling principle in the difference between one mineral and another, considered even in the most abstracted point of view, and with regard to the purest substances, as crystals, gems, &c.; as even a variation in the water of crystallisation sometimes distinguishes one mode from another. But though what are admitted as distinct modes, will perhaps always be found to differ in chemical analysis; yet as the science does not admit of too much precision, while the substances themselves are always variable, as partaking of a mutual nature, and only portions of that vast mixture the shell of the globe; the mode may also more laxly be understood to include some modifications of external characters, under what is called aggregation in particular. Thus the aggregated stones may become modes, as well as the combined. But in passing to the Structure and Aspect, the chemical characteristics may in general be considered as abandoned, or exchanged for the physical or external.

This unavoidable uncertainty has been well illustrated by the greatest of petralogists.

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[*] Bergman, the father of the system, derives the species from chemistry. See also Brochant, i. 47. Jameson, i. xxv.

Saussure's observations.

"One cannot too often repeat that there must be found in the mineral world, and that in effect in it are found, all the mixtures in all imaginable proportions, from which proceed an infinite number of mixed and undetermined kinds.

"If in the kingdom of organised beings, where the specific forms are determined by the seeds, it is often difficult to mark the limits of the species; how much more so to ascertain them in one where only the force of cohesion unites the elements, whatever be their nature, and in whatever proportion chance collects them.

"It is for this reason that in this work I have avoided giving names to the stones I have written of, when I have not been able to ascertain them by decided marks, which could fix their place in the known system of the nomenclature.

"Those who collect, and the nomenclators properly so called, do not like these doubtful sorts, which it is too difficult to arrange under the known genera. They neglect or even reject them entirely, because they appear to reproach the imperfection of their systems. For this reason one sees, in the greatest number of cabinets, only the sorts whose characters are decidedly known. There nothing stops you, all is conformable to received systems, and all have fixed names. But when nature is studied by herself, when one proposes, instead of finding cabinet specimens, to study minutely all the productions of the mineral kingdom, and is at the same time jealous of a certain degree of precision, one finds at every step individuals which it may be said to be impossible to arrange under known denominations. One may then mark the bounds; one may determine how far each individual approaches to, or recedes from, such and such a species; but one cannot positively affirm the name of the one or other of these species."*

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* Saussure, ii. 606.

§ 2. *Order of the distinctive Characters.*

The present work may be said to have passed through several editions, before its public appearance; and the portions newly modified, or finally rejected, with the detached discussions, composed in order to consolidate the progress and universal consistency of the plan, would form a moderate volume. These precautions became necessary, as upon an unknown coast the discoverer employs boats to sound the bottom, before the ship can advance with safety. Among numerous difficulties, which will be perceived in proportion to the learning of the reader, the arrangement of the characters, and the choice of one or two of the new terms, were not the least. They now stand as follow: Texture, Hardness, Fracture, Fragments, Weight, Lustre, Transparency; to which the colour is sometimes added, though the most vague and insignificant of all the characteristics.

Order proposed.

Murray, in his excellent System of Chemistry, has justly observed that it is difficult to attach precise ideas to arbitrary numbers. Every reader must have observed, that he passes without reflection the ciphers 1, 2, 3, &c. when applied to Hardness, Specific Gravity, Lustre, or Transparency. It therefore seemed more advantageous to employ terms derived from the substances themselves, which, though only relative and collective, yet convey ideas more clear, and, so to speak, more tangible than barren ciphers. In this, and other instances, the reader not conversant with modern mineralogy may perhaps be surprised at the neology: but he must be informed that the science itself is entirely new; and that there is no recent mineralogical work which does not abound with new terms, not to be found in any dictionary, but which are indispensably necessary, in order to delineate substances and qualities which did not before fall within the range of human intellect or language. The names which have been added to botany and zoology, within half a century, might be

Objections to ciphers.

Neology indispensable.

counted by hundreds; and in the progress of mineralogy, a similar neology cannot be avoided. While some recent authors of mineralogy pollute the classical language of our fathers with an inundation of barbarous German words, derived from the vulgar dialects of illiterate miners, who of course first observed the distinctions between mineral bodies; it became the more an object of ambition to treat this difficult subject with such a degree of classical purity, as not to disgust the eye of taste, contemn the discussions of grammar, or vitiate the eternal tenor of our language.

New terms. The new terms chiefly required, were to designate the degrees of hardness and weight, which had been indicated by ciphers, even by authors who used epithets to express the other characters. As Chalk, Gypsum, Marble, Basalt, Felspar, Rock Crystal, and Corundon, form various stages of hardness, at the distance of 200 or more in the common tables, they have been chosen to express the relative hardness of other substances, by the following terms: *Cretic, Gypsic, Marmoric, Basaltic, Felsparic, Crystalic, Corundic.* In order to diversify the form of the epithets, the weight has been designated by another Latin adjective termination, that in *osus*, which some grammarians affirm generally to denote weight or labour, as *laboriosus, ponderosus, operosus*, &c. and the last word has even been admitted into classical English in the form *operose*. As Pumice, Coal, Granite, Siderite, and Barytes, form a scale of gradations in weight, they are here selected to denote that quality, as being *Pumicose, Carbonose, Granitose, Siderose, Barytose*.

Hardness.

Weight.

But the characters themselves, and their arrangement, require further explanations. The Texture and Hardness occupy the first place, because adepts generally examine them first, by means of the lens and knife. Dr. Townson has observed that these instruments should always be in the pocket of a mineralogist. "With the latter, after a little practice, he will be able readily to find the hardness of most fossils; and the former will furnish him with very accurate knowledge of their texture, and be of particular use in many of his geological speculations on their formations."*

Townson's difficulties.

This skilful author has arranged his characters in the following order: Texture, Fracture, Lustre, Hardness, Fragility, Transparency, Fragments, Colour. It is hoped the present arrangement will be found more justly progressive and connected. But after having advanced several cogent arguments against Werner's arrangement, in his tenth chapter, which treats of Classification, Description, and Investigation, he strangely introduces the following remark in his ninth chapter, on the Exterior Characters of Minerals, which hence appears to have been written after the tenth. "Though I have made some objections, in my tenth chapter, to the order of the characters in the descriptions, disapproving of their beginning by their least characteristic qualities, as colour and accidental shapes; yet I perceive, were I to throw these further backward, other inconveniences would be the consequence. The characters belonging to each of the three different states of cohesion, as solid, friable, and fluid, are placed under their respective heads; but the colours, being common to all the three, are placed first." This is certainly a specimen of careless composition. The supposed inconveniences ought to have been indicated, if they did not consist in the labour, certainly not small, of altering or rewriting a system already composed, in order to render it coherent and uniform. But the forcible arguments, in his tenth chapter, remain unconfuted; and the arrangement of Werner's characters has met with other able opponents.

Werner's incongruities.

His extreme attachment to the distinction of colours, from which he has even deduced many improper, not to say absurd, appellations of mineral substances, has led him to place this vague characteristic in the first rank. The incongruity of the concatenation has been justly ridiculed in other respects. From the Lustre he passes to the Fracture, and from the Fracture to the Transparency; from the Coldness to the Weight, and from the Weight to the Smell. It would certainly have been more natural and rational to have joined the Lustre with the Colour, and the Weight with the Hardness. His idea of the successive use of the senses, in the examination of any mineral, is quite imaginary; as before an examination with a lens, it may be weighed in the hand, or its hardness tried with a knife, &c.; and it would be ridiculous to build a science upon simple exertions of the will. Independently of this new kind of pedantry, derived from German metaphysics, it is not the consideration what senses are first impressed, that should regulate the succession of characteristics; but, on the contrary, their own intrinsic importance. Hence the TEXTURE is here placed in the first rank, though totally omitted by Werner, or confounded with the fracture, with which indeed it is intimately allied: but two other celebrated mineralogists, Wiedenman and Estner, have justly introduced the texture as a characteristic of the most radical importance. In many cases it may be judged by the eye, but in most requires a lens. The hardness, which follows, may be tried by the knife or file; instruments indispensable to the mineralogist. The weight may, after some experience, be estimated by the hand; but some of the disciples of Werner have confounded this external character with the specific gravity, which belongs to the chemical class of characters.

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* Philosophy of Mineralogy, London, 1798, 8vo. p. 187.

Mr Kirwan has justly observed the inaccuracy of Werner and his disciples, who have confounded the texture with the fracture. The most minute account of the former, is that by Dr. Townson above mentioned.

Townson on the texture.

" *The Texture, Textura,*

" Is the internal structure or disposition of the matter of which a mineral is composed*.

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* " Mr. Werner says nothing on the texture of minerals; but, under the article of fracture, gives many characters which belong not to the fracture but to the texture; so that the characters of texture and fracture, though very different, are united under one head and confounded together. But in the works of

Compact *Compacta* *Dicht*	Without any distinguishable parts, or the appearance of being composed of smaller parts. Examples, Chalcedony, Flint, &c.
Earthy *Terrea* *Erdig*	When composed of very minute, almost invisible, rough parts, as clay, marl, &c.
Granular *Granulata* *Kornig*	When composed of small shapeless grains, as granulated quartz, sandstone, &c.
Globuliform *Globuliformis*	When composed of small spherical bodies, as the pisolithus and oolithus.
Fibrous *Fibrosa* *Fasrig*	When composed of fibres. Examples, Fibrous gypsum and amianthus. The fibres may be

Fine	*Tenuibus*	Parallel	*Parallelis*
Coarse	*Crassis*	Divergent	*Divergentibus*
Long	*Longis*	Stellated	*Stellatis*
Short	*Brevibus*	Fasciculated	*Fasciculatis*
Straight	*Rectis*	Decussated	*Decussatis.*
Crooked	*Curvatis*		

Radiated *Radiata*	When composed of long, narrow, flattish lamellæ. This differs from the fibrous by the parts being broader. Examples, grey antimony, manganese, zeolite, actynolite, &c. This admits of the same variations as the preceding.
Lamellar *Lamellosa*	When composed of smooth continued leaves or plates, covering one another. Example, as the spars. They may be

Straight, *Rectis*, as in most spars; or
Crooked, *Curvatis*, as in Schiefer spar; or
Spherical, *Sphæricis*, as the mica hemisphærica;
Undulating, *Undulatis*, as in talc . . . . .

Messrs. Wiedenman and Estner, there is an article under which several characters of the texture are given. Some of these I have arranged under this article; others, under that of structure or compound texture. In Mr. Werner's own work on the outward characters, this article does not exist."

Slaty *Schistosa*	Composed of thin layers or beds, as slates. As the preceding was more peculiar to the crystallised, so is this to the rupestrious fossils. As this is rather a character of structure than texture, probably it might be omitted here.
Scaly *Squamosa*	Composed of a congeries of small scales. Peculiar to the plumbago, according to Estner.
Sparry *Spathosa*	Composed of a congeries of irregular crystalline parts, like coarse salt, as the coarser kinds of scaly or saline limestone, as that of Sala in Sweden, some hornblende-schistus. This belongs to the granulated of the Wernerian school.

" In judging of the texture, attention must be paid, when it is not of the compact kind, but of the fibrous or lamellar, that it is inspected in a proper direction, which is that of its parts; otherwise, when in the opposite direction, the fibrous may appear granulated, and the lamellar radiated."

Dr. Townson says that the structure is a particular disposition of the texture, as Hornblende-slate may have a sparry texture and schistose structure; some iron ores, an earthy texture and columnar structure. Of the Structure he only indicates four kinds:

Slaty, Testaceous, Concentric, Columnar.

The first is too general, the three others too rare, to be of real utility in a general system; and this confined use of the word Structure would interfere with its general use in other senses equally appropriate.

Hardness.

The HARDNESS, another grand characteristic, may be best illustrated in Werner's own words, which will at the same time serve to convey some practical admonitions to the student.

Werner's account.

" After the particular generical characters discovered by the sight in solid fossils, follow those which may be observed by the feel, the first of which is hardness, forming the tenth in the general system.

"Upon handling different fossils, we soon perceive (to use a familiar expression) that some are softer than others. For instance, a piece of gypsum is much softer to the feel than a piece of quartz. This difference is better observed when we make use of some instrument fit for the purpose*. This is what is termed by mineralogists the investigation of hardness; and, with respect to this property, we shall divide solid fossils into *hard*, *semi-hard*, *soft*, and *very soft*.

"A fossil is called *hard* which cannot be marked or scratched by the knife; or rather which emits sparks, being struck by the steel. This degree of hardness is to be found only in fossils which are perfectly brittle (*Sprode*). Hard fossils are also distinguished into those *which are affected by the file; those which are but in a small degree;* and those *which are not in the least.* To the last belong the diamond, ruby, and emerald; in the second may be placed the topaz, rock-crystal, amethyst, flint, chalcedony, carnelian, &c. which yield a little to the file; among those on which the file takes effect, are white copper-ore, micaceous iron-ore, hematite, most compact iron stones, red and brown tin crystals, most shining grey cobalt ores (*speis kobolt*), arsenical and sulphureous pyrites, &c.

"*Semi-hard* is applied to a solid fossil which does not emit fire with steel, and which may be marked or scratched by the knife. Of this nature are *fahlers*, red copper-ore, sparry iron-ore, hard earthy lead-ore, most blendes, white shining cobalt-ore, native arsenic, kupfernikel, limestone, most calcareous spars and guhrs, fluor spar, zeolite, basalt, and many others.

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* "The instruments employed by mineralogists in this investigation are, the *knife* for semi-hard and soft fossils, the *steel* for those which are hard, and the *file* for fossils perfectly hard. The knife may also be used to judge of the streak and ductility. In order to possess a complete mineralogical apparatus, it will suffice to add to these instruments a *magnifier*, which will often he wanted to determine the exterior form and fracture, and which may be well observed with a single glass; 2. a *small phial* of *aqua fortis*, the use of which I shall disclose in the last chapter; 3. a *loadstone*, which for convenience may be so managed as to serve at the same time for a steel. If there be also added a blowpipe, in order to make essays speedily upon minerals with the assistance of fire, we shall possess all to be desired. These articles may all be met with, well made and adapted, at Mr. Schubert's, Mechanic to the Academy of Mines, Freyberg."

" *Soft* solid fossils are those which are easily affected by the knife, but receive no impression from the finger-nail. Such are white silver-ore, vitreous silver-ore, most red silver-ores, vitreous copper-ore, mountain blue-ore of copper, most bog iron-ores *(Rasen eisenstein)*, galena, compact lead-ore *(bleyschweif)*, white and green lead-ore, red phosphoric blende (from Scharfenberg near Meissen), amber, heavy spar in bars *(Stangen spat)*, mica, asbestos, serpentine, &c. &c.

" *Very soft* is applied to all solid fossils which are not only marked by the knife, but upon which the finger-nail makes an impression. Of this kind are most solid cinnabars, corneated metals, or native metallic muriats, micaceous bismuth-ore, grey ore of antimony, most earthy cobalt-ores, cobalt flowers, oxyd of native arsenic, realgar, native sulphur, mineral pitch, most pit-coal, plaster-stone, *glacies mariæ*, talc, black lead, most kinds of manganese, steatite *(Speck stein)*, amianthus, chalk, &c. &c.

" But these different degrees of hardness are so apt to approach each other, that we find each of them not only of many varieties, but very frequently observe fossils bordering upon two degrees of different hardness, which varying a little from both, forms a medium between these two degrees. For example, hard magnetic iron-stone and opal, have nearly the same hardness with semi-hard kupfernikel and basalt ; semi-hard copper pyrites and malachite approach the soft heavy spar and white lead-ore in hardness ; soft red silver-ore and amber approach the very soft cinnabar and native sulphur. It becomes therefore a matter of importance to determine the hardness of a fossil, to indicate not the principal degree of hardness alone to which it belongs, but also its relation with known fossils of the same degree, and to observe when a fossil forms a medium between two degrees. Thus, for example, we shall say that *fahlers*, or grey silver-ore, is semi-hard, but softer than copper *fahlers*, and harder than copper pyrites; that amber is soft, and forms a medium between soft and very soft fossils."*

Weight.

Not to mention the FRACTURE, FRAGMENTS, LUSTRE, and TRANSPARENCY, which are described in the common terms of most systems of mineralogy, it may be necessary to add a few words concerning the other remaining characteristic, namely, the WEIGHT. In this, as already mentioned, a relative scale is proposed, instead of ciphers, which seldom supply prompt or immediate ideas, especially as the reader generally forgets the tables prefixed. The total dismission of ciphers serves, at the same time, to render the arrangement more uniform and harmonious. The Weight has been, by many of Werner's disciples, confounded with the Specific Gravity, which requires an operation, and does not belong to the external characters of Werner; while the Weight, with some experience, may be estimated, as he says, by the hand. His epithets, however, are in this instance particularly indistinct, being *Very light, Light, Rather heavy, Heavy, Very heavy*. His scale is also too brief, five degrees being necessary for the gems and rocks, and five more for the metals. For while the specific gravity of platina is about 21, gold 19, silver 10, copper 8, iron about 7, and tin little inferior, barytes only exceeds 4; so that there is a wide transition from the heaviest stones to the metals, but not so great to the ores. To the metals, therefore, another scale should be adapted for common use. It is hoped that the one here proposed will be found sufficient for the purposes of petralogy; and it is, like the other improvements, submitted to the discussions and alterations of the intelligent in a science which is quite new and daily progressive.

§ 3. *Remarks on Werner's Geognosy, or System of Rocks.*

From the sketch imparted by Daubuisson to Brochant, and from Mr. Jameson's Geognosy, we are enabled to form an idea of Mr. Werner's system concerning the formation of such parts of this planet, as we can hope to observe, little exceeding the three thousandth part of its semi-diameter. I warmly subscribe to the sentiments of admiration which are paid to Mr. Werner's superior talents in many branches of mineralogy, a science infinitely indebted to his industry and sagacity. I also acknowledge the truth of the apophthegm, *Natura fecit omnes judices, paucos artifices*. But I regret, with his most enlightened admirers, that the scene of his inquiry has been too confined; and that his view of the mountains of Saxony has not been extended over the globe. After forty

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* Werner, Ch. Ext. p. 272.

Saussure's difficulties.

years of sedulous observation among the Alps, Saussure, who began his labours with a view of forming a system, declares that his hopes were frustrated; and that he had met with such unaccountable confusion that he could not venture to propose a theory. Yet Saussure, to practical observations on a far superior scene, added the advantages of learning, and mathematical and meteorological science, which Mr. Werner unhappily wants, and which would have corrected and greatly improved his speculations.

After describing the general appearance of the surface of the earth, and the effects of water, he proceeds to consider the structure of rocks, in their minute parts, and in their general fabric; the latter chiefly consisting of the stratified structure, and that with seams, in which last he includes

Formations.

columnar basalt. His grand doctrine of formations next appears. When the mass is uniform, as in granite, gneiss, limestone, the formation is said to be simple; but when dissimilar masses occur, as of coal and basalt, it is called compound. When the formations consist of several substances always found together, though in regions of different compositions, they are all called independent formations; but when only associated, they are called subordinate. The universal formations are found all over the globe; but partial or anomalous formations are confined to particular spots. De-

Other terms.

tached portions on the summits of hills are called caps; but when a part appears only on one side of a mountain, it is said to form a shield. When the superior strata have the same direction with the fundamental rock, they are said to be conformable with it; but when the direction is different, they are called unconformable. Sometimes they are simply unconformable, as differing only in direction; but when in addition to this they pass over the terminations of the inferior rock, they are said to be unconformable and overlying. Strata may also be strait, form a mantle around the inferior rock, cover its extremities in the shape of a saddle; or, when concave, assume the form of a bason or a trough.

Considering Mr. Jameson's work as notes taken during Mr. Werner's lectures, it may be assumed that this illustrious mineralogist then proceeds to consider the succession of the different formations. Those rocks which are always found inferior, are called Primitive; and have a crystalline appearance, intimating a chemical solution, when the water stood very high over the surface of the earth. The next class is called Transitive; which, though chiefly of chemical composition, exhibits also mechanical sediments and petrifactions. The third class consists of Stratified rocks, styled by Werner *Floetz*, signifying that they are in flat or horizontal *layers* or *beds*; a stratified rock implying that the strata are of one and the same substance; while the *Floetz*, or rocks in layers, often present beds of different substances. But this distinction is not of such utility or importance as to necessitate the introduction of a barbarous word; and if *stratified* be not precise, we may use *stratiformed* with Daubuisson. The Alluvial and Volcanic rocks form the last divisions.

Primitive.

Transitive.

Floetz.

It is to be regretted that the examples and facts are not sufficiently numerous, but even the primitive rocks seem all to be regarded as stratified, except granite, which is assumed as the universally radical rock. In the Alps, Saussure has observed that the granite presents marks of stratification. Gneiss is also found under primitive granite; and Mont Rosa, nearly equal in height to Mont Blanc, consists chiefly of gneiss and other stratified rocks. After long and diligent

Granite.

inquiry, the position that granite is the universally radical rock, would appear to be rather an assumption founded on theory, than a fact supported by proofs; for if we examine the accounts of the substances found at the greatest depths, in coal mines and other excavations, there is no appearance of granite; and if lavas often arise from a vast depth, a fact now admitted from the prodigious extent of the preceding earthquakes and other phenomena, the chief substance is iron mixed with clay; and the mineralogical appearances tend to confirm the opinion of astronomers and natural philosophers, that the nucleus of this planet consists of iron; which, even when native, is seldom found unmixed with silex, so that if any rock can be called fundamental, it must consist of such a mixture. It is true, that granite itself presents such a composition, as iron is found in the mica, and still more in the siderite, which in the oldest granites often supplies its place; and what is chiefly to be regretted, is the want of positive proofs concerning the anteriority of granite.

Dissolutions and sediments.

Werner proceeds to explain the effects of the gradual and slow diminution of the primeval waters, in producing chemical dissolutions from a great height, and afterwards gradual sediments; so that, according to his theory, the shell of this globe, instead of presenting a ruinous and unaccountable confusion, exhibits, when viewed on a large scale, a regularity and harmony, such as are admired in the other works of the great Creator.

Sequences.

Objections.

Having thus briefly explained this celebrated theory, it must be added that the rocks are divided into various formations, which often receive arbitrary and unexpected epithets. Thus the series called the SLATE FORMATION, is so named from the central member SLATE, rising to mica slate, and passing from gneiss into granite; while, on the other hand, the descent ends in coal, sand, and clay. It must strike every enlightened observer, that such a distribution, instead of leading to a just and accurate knowledge of rocks, as they occur in different parts of the world, would only form an illustration of the Wernerian system; which may, in the progress of discovery, be found, like preceding systems, to be essentially erroneous. If a work of petralogy were therefore founded upon this theory, it must fall with it: and no writer of judgement or industry would choose to risk his labour upon such an uncertain foundation. Nay, if the theory were invincible, the arrangement would still be improper for a student of petralogy; who must follow the best mineralogical authors, and arrange substances according to their chemical compositions, and other infallible rules arising from the nature and appearance of the substances themselves, whether they exist in nature or in cabinets. A general treatise on rocks therefore cannot be founded on any theory of their formation, however plausible; as the opinions of the author will be biassed by that theory, and he will be inclined, like Buffon, to reject or pass in silence any substance which interferes with his preconceptions. Thus jasper is totally omitted by Werner, though it form a chain of mountains in Siberia, of more than a thousand miles, extending even to the islands between that region and America. A disciple of Werner is therefore embarrassed when he sees specimens of rocks, not disposed in a theoretical sequence; and, in his vindication, boldly asserts that rocks can only be studied in nature, where the formations indicate the series of substances. But as this argument would be ridiculous if applied to lithology, or the knowledge of small or precious stones, so it is equally inapplicable to petralogy; the distinctions between large stones being as certain, and still more useful to society. The knowledge of small and precious stones has been accompanied and greatly assisted by the constant introduction of new denominations, which at present amount to about two hundred; while the rocks of Werner do not exceed sixty, although the distinctions between the rocks be not only more numerous, but more apparent than those between the parasitical stones. If the systems of botany and zoology were founded on progressive formations, it is evident that no two authors could agree upon the links of the chain; and such systems have accordingly been founded upon characteristics derived from their exterior forms; while, in mineralogy, the forms of the greater masses being casual and uncertain, recourse must be had to chemical analysis, as well as to exterior qualities. But, in the former, it is not so much the substances forming the combination, as the mode or manner of that combination, which constitutes the essential difference among the objects of mineralogical knowledge; for the diamond is only a modification of coal, and the sapphire of clay and iron rust. Hence, while the mode of the chemical combination establishes the most essential difference, the structure and the aspect constitute more minute distinctions. It may also be observed, that Werner's method of distinguishing rocks, by their formations and positions, seems at variance with his treatise on the external characters of minerals, in which the science is rightly founded on its only firm foundations, those depending on the characteristics of the substances, as considered in themselves. This object was perhaps considered by Werner as already accomplished in that treatise, and in his lectures on Oryctognosy, or the general knowledge of minerals: but the rocks form a class so important and distinct, that they deserved a separate consideration, before proceeding to the bold design of general geognosy or geology. Perhaps the experience and observations of two centuries may still be wanted, before such a design can be reasonably attempted; and at present the Huttonian system has as many admirers as the Wernerian, though founded on principles totally opposite: but, in all events, it was necessary to begin with an elementary work, containing all the erudition already acquired on the subject, leading to more clear and precise views, or exact distinctions, and a consequent increase of denominations, without which even theory must be embarrassed; for at present it is not even agreed what object precisely constitutes granite, and what object basalt. All theories, however, tend to the advancement of science, by stimulating inquiry and discussion; but it is clear that the theories must be vague, and the contests alike fruitless and endless, till the parties shall have agreed

Necessity of new names and definitions.

upon the denominations and definitions. For what hope of any reconcilement of opinions, or any clear knowledge, when the French persist at this moment in regarding basalt as compact lava; while Dolomieu, the greatest of their mineralogists, and at the same time a practical and sedulous observer of volcanoes, has loudly declared that the basalt of the ancients is never a volcanic product?

Petralogy therefore, or the knowledge of rocks, must, like the other branches of mineralogy, be studied in cabinets as well as in nature; and in the substances themselves, not in supposed theoretical positions: for if the student cannot distinguish a rock without these adventitious aids, which in the great variety of nature will themselves often lead to false conclusions, he may be pronounced as truly ignorant of the subject, as he who cannot distinguish gems without being informed of their countries, sites, and gangarts. And this would be the more absurd as it is self-evident, as already observed, that large substances must present more palpable and more numerous distinguishing characteristics than the minute.

It must also be considered that Werner, by founding the knowledge of rocks on a system of geognosy, has been led by juxta-positions, and other accidental circumstances, observed in the confined scale of Saxony, to diminish rather than to enlarge the number of denominations; the result of which practice would evidently be to obstruct the progress of the science; and, as he is not versed in erudition, his own denominations are sometimes unclassical, and so vague, as to give no positive idea; of which examples may be found in his flinty slate, his slate porphyry, and his white-stone. Indeed his new denominations in lithology being often founded on colour, have been sometimes rejected*. To institute new denominations, it is evident that erudition is necessary; and this leads me to observe, that the study of preceding works

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* When he classes the gems as siliceous, instead of argillaceous, he confounds them with the false gems (rock crystals, &c.), which are siliceous.

Studies requisite.

on the subject is indispensable to a complete treatise on petralogy, which should enable the student not only to know the substance, but the denominations used by former mineralogists and travellers, and by historians, philosophers, and poets, which will not only enlarge his ideas but give him more accurate knowledge. And as few of the sciences can be founded on personal observations, *vita brevis, ars longa*, and the brevity of human life will not permit a petralogist to pass forty years in the Alps with Saussure, thirty in Saxony with Werner, &c. &c. he will of course acquire infinitely more knowledge by the study of their works, than by any personal observations; so that this science, like all others, results from accumulated knowledge.

These observations shall be concluded with Werner's arrangement of the rocks.

Werner's rocks.

CLASS I. *Primitive Rocks.*

1 Granite.
2 Gneiss.
3 Mica Slate.
4 Clay Slate.
5 Primitive Limestone.
6 Primitive Trap.
7 Serpentine.
8 Porphyry.
9 Sienite.
10 Topaz Rock.
11 Quartz Rock.
12 Primitive Flinty Slate.
13 Primitive Gypsum.
14 White-Stone.

CLASS II. *Transitive Rocks.*

1 Transitive Limestone.
2 Transitive Trap.
3 Grey Wacke.
4 Transitive Flinty Slate.
5 Transitive Gypsum.

CLASS III. *Floetz or Stratiform Rocks.*

1 Old Red Sandstone, or first Sandstone Formation.
2 First, or oldest Floetz Limestone.
3 First, or oldest Floetz Gypsum.
4 Second, or variegated Sandstone Formation.
5 Second Floetz Gypsum.

6 Second Floetz Limestone.
7 Third Floetz Sandstone.
8 Rock Salt Formation.
9 Chalk Formation.
10 Floetz Trap Formation.
11 Independent Coal Formation.
12 Newest Floetz Trap Formation.

CLASS IV. *Alluvial Rocks.*

1 Peat.
2 Sand and Gravel.
3 Loam.
4 Bog Iron Ore.
5 Nagelfluh.
6 Calc-tuff.
7 Calc-sinter.

CLASS V. *Volcanic Rocks.*

Pseudo Volcanic Rocks.

1 Burnt Clay.
2 Porcelain Jasper.
3 Earth-Slag.
4 Columnar Clay Ironstone.
5 Polier, or Polishing Slate.

True Volcanic Rocks.

1 Ejected Stones and Ashes.
2 Different Kinds of Lava.
3 The Matter of muddy Eruptions.

§ 4. *Admission of Iron as an Earth.*

Admitted by former authors.

The admission of iron, not as a metal, but as an earth, may occasion some hesitation; and a few preliminary observations become necessary. Many eminent mineralogists and geologists have led the way to this improvement, though they have not formally introduced it into a system. It may be preferable to adduce their testimonies in chronological order.

Linneus.

Linneus has thus expressed himself, in his brief and emphatic language: "I have sedulously enquired, during my various travels, into the production of stones, and have learned that it is effected by precipitation and crystallisation; and that earths are deposited, while quartz, felspar, and mica rise up. The female earths are impregnated by the male salts, whence a more noble progeny; but many of the latter are derived from Iron, a Proteus who changes according to the disposition of each wife."*

Influence of iron.

He thus insinuates his opinion of the wide influence of iron, a metal which belongs to all ages and formations; and whose power is prodigious and perpetual, even in animal and vegetable life. Bergman has indeed asserted a similar wide diffusion of gold, which has escaped the more recent and precise tests of chemistry, and is now rather regarded as imaginary; while the most numerous and exact experiments more and more evince the universality of iron, which drops even from the atmosphere as the chief ingredient of what are called meteoric stones, and supplies volcanoes from the lowest abysses of the earth. Iron, the grandest of the metals, is not only the most widely diffused, but the most useful to mankind in all the stages of society, and without it civilisation would be unknown; as it furnishes the spade and the plough to the agricultor, tools to the artisan, the compass to the mariner, armour and weapons to the hero, and ink to the eternal theme of the author. But waving these considerations, Linneus has thus sufficiently expressed his opinion of its influence in the constitution of rocks and stones.

Cronstedt.

Cronstedt, who may be called the grandfather of modern mineralogy, as Bergman is the father, had long ago a faint discovery of this truth; for among his nine earths, several of which have since been discarded, he reckons Garnet Earth, which, as that substance is strongly impregnated with iron, can only be the siderous earth here mentioned.

Bergman.

Bergman also, in his Sciagraphia, which laid the foundations of modern mineralogy, especially reckons the ferruginous among the six principal earths, as he includes the barytic. In his account of carbonate of lime, he mentions that it is seldom free from iron, which is found even in the most transparent, the calcareous spar of Iceland; "and it may be said in general that all minerals contain that metal."[*]

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* Lithogenesiam studiose in itineribus quæsivi, dedicique eam absolvi Præcipitatione et Crystallisatione; atque Terras prosterni, sed Quartzum, Spatum, Micamque, exsurgere. Terras femineas dein impregnari a Salibus masculis, indeque prognasci Nobiliores; horum vero plurimos a Marte, Proteo magis mutabili, pro indole cujuscunque conjugis. *Linn. a Gmelin*, p. 4.

Kirwan.

To these eminent testimonies may be added Kirwan, who has nearly approached to this division; for, after describing the simple earths, he proceeds as follows:

"*Calces of Iron.* To these simple earths we must also annex the consideration of calces of iron, as they almost always accompany earthy or stony substances, are mixed or combined with them, and are the source of many both of their external appearances and internal properties.

"Calces of iron are formed of iron, combined with different proportions of pure air, and frequently of water also, and fixed air.

"One hundred parts metallic iron are capable of taking up 66 or 70 of pure air. When 100 parts iron contain but 40 of this air, the compound is still magnetic."[†]

In another place, after observing that any earth which forms less than one twentieth of a compound, is seldom of any importance, he proceeds to state that calces of iron influence in some measure the properties of a compound, even when they do not exceed one thirty-third part of the whole, that is, three in the hundred; and if they be themselves magnetic, they communicate that property to compounds of which they form above one tenth[‡].

In a later production, and with more ample information, he presents the following remarks. "The proportion of the different materials contained in the chaotic fluid to each other, may be supposed upon the whole nearly the same as that which they at present bear to each other; the siliceous earth being by far the most copious; next to that, the ferruginous; then the argillaceous and calcareous; lastly, the magnesian, barytic, Scottish, and Jargonic, in the order in which they are named; the metallic substances (except iron) most sparingly." After such illustrious authors, it is scarcely necessary to mention the similar ideas of Lametherie*.

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[*] Fr. tr. 1792, i. 170. ii. 378.

[†] Min. i. 17. Calces were powders, now called oxyds. Thomson, i. 132.

[‡] Ib. p. 48. In his treatise on the Magnet (Mem. R. I. A. vi.), Mr. Kirwan says that iron abounds in all minerals, from 2 to 25, but at a medium 6. This globe, he adds, is 4.5 heavier than water; and, p. 182, thinks the centre iron; and afterwards calls it a great magnet, in which Haüy coincides.

Dolomieu.

In his celebrated memoir on rocks, Dolomieu observes that they are chiefly composed of four principal earths, to which may be joined iron, or the earth which produces it: and he adds that, in this memoir, "he never considers iron under the relation of its metallic properties, but as a simple earth, susceptible of the same kinds of combination as the other elementary earths."† In his theory, Dolomieu supposes that the precipitation of the principal earths took place in the following order: the siliceous, the argillaceous, the magnesian; contemporary with which two last, was that of the ferruginous, or, as it is here denominated from the Greek, siderous; and last of all the calcareous‡.

In the continuation of this memoir he considers the aggregation of the five principal earths, estimated according to its comparative force, to be in the following arrangement: siliceous, argillaceous, ferruginous, calcareous, and magnesian. He remarks, as a singularity in the ferruginous earth, that it often lends more hardness and solidity to masses where it is simply mingled, than it can acquire when it is in a state of purity. He afterwards proceeds to various observations on the force of adhesion of these five principal earths, and gives a table to illustrate this quality.

Patrin.

Patrin, who often looks upon nature with an original and inquisitive eye, has introduced many illustrations of the necessity of the siderous division. Among the primitive schisti he enumerates "Ferruginous Slate. This slate is chiefly composed of indurated clay, abundantly mixed with Oxyd of Iron, either black or brown, but sometimes yellow or red, with a little quartz, and a considerable portion of mica. This rock is one of the most common in the northern countries, where iron is singularly abundant. The eastern side of the Ural mountains, for an extent of about five hundred leagues, from north to south, is almost entirely composed of it." He afterwards observes, that in Siberia many mountains are composed of trap or basalt, " containing masses or veins of granite; while the granitic mountains often contain veins and masses of trap or hornblende."* This last observation may be universally extended; and evinces that siderite, and even trap or basaltin, is at least as ancient as granite, which has *hitherto* been gratuitously admitted as the most *ancient of* all the rocks. He also adds, that he has seen large mountains of hornblende, or siderite, in the Altaian chain†.

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* Theorie de la Terre, Tome i. p. 435. Tome iv. p. 45, &c.

† Journ. de Physique, Tome 39, for 1791, p. 374.

‡ Ib. 382.

In treating of iron, Patrin observes that the veins or beds of iron ore, are constantly parallel to the beds of the rock, which in the primitive mountains are often vertical, and seem from the first to have formed an integral part of the mountain which contains them; whence Buffon has called them primordial mines; whilst the veins of other metals almost always intersect these beds under different angles, sometimes even at right angles, and evidently appear to have been of a formation posterior to that of the rock. He proceeds to observe that the mountain of Blagodat, on the eastern side of the chain of Ural, consists of thick beds of iron, separated by others of slate and a kind of trap. In that of Keskanar, in the same quarter, the celebrated magnets are mixed with a quantity of greenish siderite in small spots, and extremely resplendent when the stone is polished. In the Altaian chain, vertical beds of an ochry slate alternate with compact beds of black iron ore. The primordial beds are chiefly composed of black iron ore, often magnetic; the strongest magnets of Siberia being those which present laminar parts, sometimes of iron, sometimes of hornblende or serpentine. The nucleus of the earth, as he observes, must be chiefly ferruginous, as is not only announced by the general phenomena of magnetism, but by the observations and experiments of Maskelyne and Cavendish, which show that the specific weight doubles that of rock crystal*.

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* Min. i. 120, 127.

† Ib. 182.

In his mineralogy, Patrin begins with a description of the primitive rocks, which he introduces by that of the chief substances of which they are composed, namely, quartz, felspar, mica, and schorl. This last term is generally used by the French geologists for siderite or hornblende. "Often," says Patrin, "it forms considerable masses of rock, and even entire mountains. When the schorl-rock presents a distinct laminar texture, it is called hornblende; when the texture is of an earthy appearance, it is named *Cornéene*." This last word is often used by the French for basaltin. Thus, in the opinion of this great observer, who has passed many years in the mountains of Siberia, schorl or hornblende, composed of siderous earth, is as primitive as any of the rocks†.

Magnetism.

But while these great geologists admit the ferruginous or siderous among the principal earths, they seem never to have connected this idea with that of most writers on magnetism; who, in order to explain that phenomenon, are forced to admit that the nucleus of this our planet is a mass of iron: and as, according to all theories, the substance which is nearest the centre must be the most ancient, of course the siderous earth must often partake of this antiquity; and instead of ranking it, with Dolomieu, in the third or fourth succession, it may be more properly classed in the first. In the mica of granite, and often in the felspar, and even in the quartz, a portion of iron is discoverable: and basalt, which contains a large portion of iron, is sometimes intermixed with primeval granite*. In the other most ancient rocks, particularly those of hornblende or siderite, iron also abounds; as it does in jasper, common slate, trap, serpentine, and the oldest sandstone.

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* Min. v. 11, 48, 241. The mountains of Selinga, he says, are chiefly of hornschieffer and hornblende.

† Siderite and schorl shoot across quartz and felspar, so are more ancient: so siderite and basalt intersect granite.

It may be necessary, however, to introduce a distinction between the Siderous Earth and metallic iron, which must depend upon the proportion to be found in various substances. As the alkaline earths, though they yield metals, will scarcely by any mineralogist be classed among metallic substances; so Siderous Earth, though it yield iron, may be admitted among the other principal substances of that class. In fact, as the recent discoveries of Dr. Davy evince that the alkaline earths, *that is the calcareous*, magnesian, barytic, strontianic, are of a metallic nature or yield peculiar metals, while he suspects the other earths to be in the like predicament (as the siliceous has since proved), it would be absurd to reject iron as an earth, merely because it yields a metal.

Dr. Davy's discoveries.

It has already been seen that the presence of this earth, even in a small quantity, is so powerful as greatly to affect the compound; and, by altering the quality of its mode, even to change its substance and denomination. Among many examples may be mentioned the hyalite of Dauphiny, which only contains 10 of iron in 100, yet the form of the crystals is that of the iron ore of Elba. Many mineral substances receive their denominations, not from the abundance, but from the influence of particular earths; for the greater part of the argillaceous and talcous rocks contain two thirds or three quarters of silex; so that if the abundance alone were regarded, two of the chief denominations of the mineral kingdom would be rejected. In many instances, the energy of one ingredient has far more force than the abundance of another. An able chemist, after discussing some difficulties of this kind, thus proceeds: "These circumstances no doubt arise from the modes of chemical analysis

Power of iron.

Energy of ingredients.

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* The granite of the Hartz even affects the Magnet. Jam. Min. Sc. Isles, p. 65.

being yet imperfect; and particularly from our being still almost wholly ignorant of what determines the properties of compounds so complicated as minerals generally are. All the ingredients are not to be regarded as equally energetic, or as in the same proportion contributing to the peculiar constitution of a compound; and if one, which in its relation to others is comparatively feeble in its action, be present in large proportion, it leads to erroneous conclusions, when, in determining composition, we attend merely to the relative quantities of the principles, without attending to their relative energies. This has been generally hitherto done; and among the earthy fossils, the predominating principle has always been regarded as that which is present in largest proportion, though the reverse is probably frequently just."[*]

§ 5. *Miscellaneous Observations.*

This introduction shall be closed with some miscellaneous remarks, which may not be found unuseful for the previous consideration of the reader.

The science too extensive.

A grand cause, as elsewhere observed, of the slow progress of mineralogy, when compared with other parts of natural history, is that it is too wide for the labours of one man; whence some important parts have remained uncultivated, while others, often comparatively minute, have been discussed with great care and anxiety, according to the peculiar studies and inclinations of the several authors. The progress of zoology and botany has been greatly assisted by the publication of detached works upon several divisions; and even the mosses and lichens have been found sufficient for one man's attention, in the brevity of human existence. Recent authors upon these two kingdoms have hence been enabled to glean the most interesting topics, and to form general compilations of great merit and accuracy. For as *vita brevis, ars longa*, was the axiom of Hippocrates, who compiled his classical productions on medicine from cases preserved in the temples, so in all the other sciences, the mere observations of one man will not constitute a science or a system. Saussure passed forty years amongst the Alps; and if the years consumed by other travellers and authors, whose works have been used in the present compilation, were computed, they might amount to a thousand; a period belonging to nature and science, but not to man. Hence the utility of general systems or *compilations*, which, by combining in one view the observations of practical or scientific predecessors, not only by collation and elision render them more intelligible, but ascertain the progress attained by any science; so that future diligence may not be wasted in the investigation of subjects already illustrated, but be directed to such parts as remain uncultivated and obscure. In this also, as in the other sciences, more genius is required to build a system, than to make observations. In the latter, Newton must yield to Herschel.

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[*] Murray's Chemistry, iii. 7. He had already said, p. 5, "each simple earth giving its name to an Order, under which are arranged the fossils in which it is *predominant*, or to which it gives a *predominating character*." And so Bergman, the father of modern mineralogy, in the preface to his *Sciagraphia*, 1782: "I have derived the *genera* from the *dominant* principle; and the *species* from the diverse mixtures."

Utility of compilations.

As the study of mineralogy commenced upon principles afterwards found to be inadequate and erroneous; so, by a similar fatality, the study of rocks has been confounded with what is called geology, or the doctrine of the constitution of this globe, which rather belongs to natural philosophy. Petralogy, like lithology, or metallogy, is a science which must be studied by the geologist; but a theory of the earth may as well be studied in a pebble, as in a rock; and the neglected plains, as being nearer the centre of the earth, must afford more topics than the lofty rocks and the mountains. There is no reason, therefore, particularly to connect petralogy with geology, or what some call geognosy: and it would be alike absurd and useless if a rock could not be classed, without a dissertation to determine its antiquity. Nor can any reason be perceived why Werner should regard

Petralogy differs from geology.

empirical characters as the chief in regard to the rocks, while he justly considers them as the last and meanest in the consideration of other mineral substances. Here, as in other provinces of the mineral kingdom, there is no infallible guide but Chemistry; upon which alone a rational and durable system can be founded. And if, as some few suppose, chemical operations lead us to educts instead of products, the difference remains the same, and the distinctions equally clear.

Futility of little tours.

Yet some ingenious men, who have made a tour of a few hundred miles, aspire to the study of geology, and speak of their observations with all the pride of ignorance, and all the vaunts of enterprise; while one simple perusal of Saussure's work would teach them that they knew nothing. In the momentary duration of human life, as man writes with his hand on the table and his foot in the grave, infinitely more knowledge must be acquired by the study of former authors, than by trifling observations, which would probably not even have been made if the fugitive traveller had previously studied the subject, or had even once revisited the spot, as Ferrara has observed of Dolomieu. While an author in his cabinet studies the whole globe, and the collective labours of two thousand years, these little journeys only impress him as puerile excursions; and, in conversation, he regrets to find the smallest tourists the greatest boasters. Da Costa has illustrated this truth by a ludicrous story: Dr. Meara, having the greatest respect for his own abilities, and regarding his own discoveries with much admiration, was travelling on Landsdown near Bath, when he observed a kind of chalk, of quite a new species if not genus, being of a white colour, remarkably pure, but above all very hot in the mouth; and in consequence he wrote a dissertation to prove that this chalk alone was the long investigated cause of the heat of the Bath waters. This celebrated discovery has passed into the last edition of the valuable mineralogy of Wallerius, who even quotes Da Costa as his authority for this new chalk, though that patient writer had only mentioned it, to inform his readers that it was unslacked lime, which had fallen from a broken cart.

Study of rocks.

Such tourists, while they have themselves seen as little as they have read, are as loud as Dr. Meara in their assertions that rocks can only be studied in nature; while, in fact, it is as impossible to discern rocks from nature alone, as from books alone. The one must assist the other. The vagueness of ideas in the works of Dolomieu and Faujas, and many other observers, is such that nothing can be learned. But how distinguish rocks, or acquire accurate knowledge, from works of which the authors cannot distinguish a granite from a porphyry, &c.? If, in zoology, a horse was called a lion by one writer, a tiger by another, a leopard by a third, and a panther by a fourth, what knowledge could be acquired? or if, in botany, the rose of one author was the lily of another, while others styled it by a hundred different names? While Buffon and his disciples speak with contempt of nomenclature, they might as well tell us that in civil history the actions of Pompey might be ascribed to Cæsar, and those of Anthony to Cleopatra, for of what consequence are names? Saussure, with his usual judgement, pursued a very different course; and the most laborious parts of his work are evidently those in which he attempts to establish a precise nomenclature. It may safely be asserted that the science can have no foundation till a precise and rich nomenclature be established; and that till then it will remain a chaos, and not a world.

Necessity of exact nomenclature.

The student of rocks must therefore begin with a precise nomenclature, as otherwise his observations cannot be of the smallest utility. If he mean to pursue this study, he may also find it more interesting to pass from this arid subject to the beauties of crystallisation and the metals; and thus from great and general ideas descend to minute. The student of zoology would scarcely begin with entomology. But even among the authors of mineralogy there are ore and dross: and who would believe that an hundred authors have fallen into the grossest errors concerning ophite, &c. because they neglected to consult the original passages?

Apology for this work.

In the present work, it is hoped that the want of attention, care, or labour, will not be accused. The author has sedulously employed the intervals of ten years in this production, particularly three which he passed at Paris, where he had constant opportunities of seeing the most opulent cabinets, and of conversing with men eminent in the science, as Patrin, Gillet Laumont, Daubuisson, and others; not to mention interviews with Haüy, and with Werner during his short stay in that capital. It was resumed at intervals of other studies, the change of labour being itself an amusement. He hopes the work may at least aspire to the humble praise of utility, the chief aim of his labours: *terar dum prosim.* In the preface to his grand treasure of ancient knowledge, Pliny has observed that it is laudable to mention the authors by whose works you profit. Not contented with exact references, the author has often adduced the original passages, not only for the sake of greater accuracy, but to save the reader the trouble and expense of consulting many works, which perhaps contain only a few pages on this particular subject, which has hitherto been treated as a mere appendage to mineralogy. There are also numerous extracts of great value, from works in foreign languages, of which, from their nature, the English reader can scarcely ever expect to see complete translations. These extracts will, it is hoped, from the variety of the style, throw some flowers over a subject proverbially barren; while the expressions of the observers themselves, in the sensations arising from grand phenomena, sometimes enliven the subject with somewhat of a dramatic interest. It must also be remembered, that mosaic is even more difficult than painting, and of incomparably longer duration. Some regard it as a maxim in literature, that a book should be as complete in itself as possible; and a reference to a work, which he can neither procure nor read, would contribute little to the instruction of the learner. The candid will likewise consider the entire novelty of the plan;

which, while it required a minute attention to the congruity of the parts, must also, like a new road, lead to mistakes and deviations, perhaps more numerous than the author can conceive; and which, if pointed out with benevolence, he will be ever ready to correct with gratitude. "Those who have gone before us," says an ancient classic, "have done much, but they have not finished; much labour still remains, and much will remain; nor will an occasion be wanting of adding somewhat even to authors who shall be born after a thousand ages."[*]

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[*] Sane multum illi egerunt, qui ante nos fuerunt, sed non peregerunt; multum adhuc restat operis, multumque restabit, nec ulli nato post mille secula præcludetur occasio aliquid adjiciendi. SENECA.

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CORRECTIONS AND ADDITIONS.

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P. 21, Note. Comparė Ferrara's accounts in Dom. XII.

85, Note. Verd d'oeillet may be the peculiar light sea green of the *grass*, or leaves, of some pinks or carnations.

98, l. 13. *For* Eisenthorn, *read* Eisenthon.

106, l. 21. The analysis of Slate and Mica Slate, by Daubuisson, is in the Journ. de Ph. Juin 1809.

Silex	48, 6
Argil	23, 5
Magnesia	1, 6
Peroxyd of Iron	11, 3
Oxydated Manganese	5
Potash	4, 7
Carbon	0, 3
Sulphur	0, 1
Water and Volatiles	7, 6
	98, 2
Loss	1, 8
	100.

This he compares with Klaproth's analysis of Mica, which yielded, Silex 47, Argil 20, Oxyd of Iron 15, of Manganese 2, Potash 15.

137. Col. Imrie (Tr. Wern. Soc. i. 454), says, the glutenite near Stonehaven consists of pebbles of quartz and porphyry, with some of jasper, hornblende, hornstone, cemented by a reddish brown ferruginous clay, mixed with minute particles of quartz and mica, but which only fills the intervals. At Oban

the cement appears a blackish grey indurated sand, composed of argil, fine sand, black oxyd of iron, and is slightly coherent. It is singular that this glutenite is vertical on the E. and horizontal on the W.

P. 155, Note. The *Black Forest* Mountains form another example.

167, Note. *For* ava, *read* lava.

374, Note. *For* Voyage, *read* Journey.

345, l. 8. *For* Marbois, *read* Marboré.

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64. Compare the sites of Miagite in the Appendix.

100, l. 2. *For* resemble to, *read* resemble.

221, l. 2. *For* Roy. *read* Roz. that is, the Journ. de Ph. by Roziere.

267. The following account of the fall of Rosenberg may not be unacceptable.

" On the 2d September, 1806, at five in the evening, the Knippenouhl Rock, which formed the summit of Mount Rosenberg, was on a sudden detached from its situation; and at the same time part of the mountain, of several feet thick, on the western side, and about 280 feet thick on the east side, gave way, and fell into the valley which separates the lake of Zug from that of Lauwertz. One part of the mountain fell into the lake of Lauwertz, which caused such an agitation in the waters of the lake, that they overthrew a number of houses, chapels, mills, &c., along the southern shore. Upwards of one thousand persons were the victims of this calamity. A society of thirteen travellers were on the road from Arth to Schwitz: nine, who walked first, perished; the other four escaped. In this convulsion enormous pieces of rock were carried through the air to prodigious distances. The lake of Lauwertz has lost above a quarter of its extent. That rich plain which was so beautiful, now presents a mountain of near one hundred feet in height, a league and a half in length, and as much in breadth. The villages of Goldau and Rothen, consisting of one hundred and fifteen houses; that of Busingen, of one hundred and twenty-six; and that of Kuslock, have totally disappeared. Of Lauwertz, which lost twenty-five houses, there remain ten buildings, all much damaged. Twenty years since general Pfyffer predicted this catastrophe, from the knowledge that he had of the nature of the mountain. A professor of Schwitz said, that above Spietsfleu was a sea of water, which had undermined the rock for several years, and that below there was a cavern of great depth, where the waters were engulphed. The quantity of water which has fallen during the preceding years has hastened this catastrophe, and the rains of some weeks past have decided it. On the 10th eight hundred persons were employed in digging for the bodies of those who were destroyed by the falling of the mountain at Schwitz. In forming a channel to draw off the waters, between thirty and forty labourers were swallowed up by a torrent of muddy water, which broke in upon them suddenly."*

Besides the plates and description published at Paris, there are three large views drawn and engraved by Wiebel, a Swiss artist, which the author has seen. The effect is not that of a fallen cliff, as in granitic mountains, but that of masses of rock, detached and thrown down a gentle declivity, with such impetus as to overwhelm every obstacle, and spread to an amazing distance.

P. 306, l. 5. *For* tufa, *read* tufo.

401, l. 16. *For* PRODUCTION, *read* PRODUCTIONS.

428, *Marginal indication. For* Former rocks, *read* Forms rocks.

---

* Annual Reg. 1806, p. 448.

G. Cooke, Fecit

Grand Cavern. Staffa

DOMAIN I.

SIDEROUS.

◆

SIDEGEA, SIDEROUS EARTH.

THE name *sidegea*, as not unusual in compounded words, is abbreviated from two Greek terms, signifying iron and earth. The reasons for the introduction of this grand division, adopted in substance by the most eminent geologists, have already been given. Iron acts so important and radical a part in the constitution of our planet, that it deserves to be viewed under various aspects, not only as a metal, but as an earth, strongly impregnating most of the others, and often exerting a predominating influence. For as, since the recent discoveries, many earths have been known to assume the form of metals, so there can be no impropriety in considering this universal metal under the form of an earth.

When a substance contains more than twenty-five parts in the hundred, or, in other words, one quarter, of iron, it may be worked as a metallic ore, and arranged under that denomination. But in a smaller quantity it will fall under the present division, especially when intimately combined with the other earths. It was by metallogists considered as a calx, or latterly called an oxyd. Mr. Kirwan*, who has rightly added calces of iron to his description of the earths, says, that they are formed of that metal, combined with different proportions of pure air, and frequently of water also and fixed air.

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* Min. i. 17.

"One hundred parts metallic iron are capable of taking up 66 or 70 of pure air. When 100 parts iron contain but 40 of this air, the compound is still magnetic." His table of the fusibility of the simple earths presents some curious experiments on the mixture of calcined iron and rust of iron, with other substances, which show the power of this metal. Even when it only amounts to four parts in the hundred, it sensibly influences the compound.

Sidegea, or siderous earth, is so generally diffused, that almost every mineral substance derives its colour from it, from a pale blue to the deepest red. Animal substances contain it; and it exists in the vegetable kingdom, even in plants apparently supported merely by air and water. It would appear that even the atmosphere abounds with atoms of iron, whence perhaps the meteoric stones.

MODE I. SIDERITE.

Distinctive characters.

Texture, generally crystalline, as in the saline or primitive marbles; the prisms sometimes intersecting each other, so that it becomes difficult to determine their figure*. The grains are sometimes so small that it assumes a compact appearance, in which case it passes into basalt.

Hardness, basaltic, sometimes only marmoric. Fracture commonly foliated, sometimes radiated, tough. Fragments rather sharp.

Weight, siderose: sometimes approaching the barytose.

Lustre, splendent, shining, between vitreous and pearly. Opake; the green sometimes translucent on the edges.

Colour generally black, sometimes of a greenish grey.

Siderite sometimes composes entire mountains, but more commonly occurs disseminated, or forming veins or nodules, in granite; or beds in gneiss.

Hornblende.

This important substance, which is so widely disseminated, is the *hornblende* of the German miners; a barbarous term, which, like many others, had passed into the science before it became classical*.

---

* The crystals of siderite are of an oblong quadrilateral form, while those of mica are hexagonal.

"Mountains of black hornblende exist in Siberia, Renovantz, 32: as the Tigereck, 4 Nev. Nord. Beytr. 192; and others mentioned by 2 Herm. 271. Frequently mixed with quartz, mica, or felspar, or shorl, and either greenish or black. Ibid. But it is more commonly found in mighty strata, as in Saxony; or still oftener as a constituent part of other primeval rocks, as in syenite and grunstein; sometimes in layers in gneiss, or granular limestone, or argillite; and sometimes in horn porphyry. 2 Berg. Jour. 1788. 508. 1 Lenz. 325. 1 Emmerling, 325; or in the gullies of granite. Herm. Ibid. Hornblende slate was observed among the primeval rocks on the ascent of Mont Blanc, 7 Sauss. 241, 253, mixed with plumbago; Ibid. and on its summit, Ibid. 289." Sites.

"Strata of schistose hornblende occur sometimes in gneiss, as already mentioned. At Miltiz a stratum of it has been found over granular limestone. Voigt Prack. 33. In Lower Silesia it has been found on syenite. 4 Berl. Beob, 349. Granite sometimes rests on it. 2 Berg. Jour. 1790, 300. Voigt Mineral. Abhaudl. 25. Hence there can be no doubt of its being a primitive stone. A mountain of it exists in Transylvania; 1 Bergb. 40. Nay, granite has been found in it. 1 Berg. Jour. 1789, 171. It is frequently mixed with mica, more rarely with visible quartz: Emmerling*."

---

* *Blend*, in German, sometimes implies *blind*, sometimes *false* or *deceitful*; but the name seems rather to have arisen from its having the appearance of *blende*, an ore of zinc, which was also called *pseudo galena*. *Blend*, or in modern German *blind*, never has the final *e*: and there would be no sense in *blind horn*. But as the substance much resembles black *blende*, and, when struck, often crumples like horn, the etymology is very clear. A French writer rightly translates it *Blende de corne*. Hornstein and Hornsilver are *translucent as horn*.

Patrin observed in Siberia many mountains entirely composed of siderite, and containing masses or veins of granite; while reciprocally the mountains of granite often present veins and masses of siderite†. These accidents are particularly frequent in that part of the Altaian mountains which approaches the river Irtish.

It also abounds in Bohemia, Saxony, Tyrol, and many other countries, not to mention the isles of Arran, Col, and Tirey; the district between Lochlomond and Dunkeld, and other parts of the Highlands of Scotland; and also near Holyhead in Wales.

Saussure describes, § 674, a strange mixture of massive granite with a grey heavy rock, which on the outside appeared of a rust-colour. This is evidently a siderite, of which the iron is decomposed. He justly observes, that both must have crystallised together, and of course siderite must be as ancient as granite*.

---

* Kirwan Geol. Ess. p. 181.

† Min. i. 127.

The rocks of siderite are by Werner classed among the Primitive Traps, which he divides into the common, the granular, and the schistose; with two mixtures, siderite with felspar and with mica. The admixtion of mica and pyrites is by Daubuisson regarded as characteristic of the primary traps. That of siderite and felspar constitutes the primitive *grunstein* of Werner, including the common, the porphyritic, the grunstein porphyry, the green porphyry of the ancients, and grunstein slate; which latter has, according to Daubuisson, been called *hornschiefer*. Some of these primitive traps have been arranged under the large and vague denomination of *cornéenne*, *roche de corne*, *pierre de corne*†, by the French mineralogists; and even by Saussure, who tells us, § 1225, that when the *cornéenne*, or *pierre de corne*, has marks of crystallisation, it assumes the name of *hornblende*. But as the stones, confessedly called basalts by

Primitive trap.

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* The summit of the Dome du Gouté consists of siderite in a state of decomposition. Id. § 1980.

† *La pierre cornée* is petrosilex.

the ancients, often present marks of crystallisation, being sideritic rocks or primitive traps, they shall be considered under that division. Wad, in his account of the Egyptian minerals in the Borgian Museum*, observes, that the basaltic monuments of the ancients are referable to two classes; 1. The primitive, consisting of black hornblende, or siderite, which is sometimes so mingled with veins of felspar, and often with quartz and felspar, partly rude partly crystallised, that it is in some examples difficult to determine whether they should be placed among the basalts, or syenites, of Werner. 2. This class appears of more recent formation, and in all respects agrees with the basalt of Werner, except that it be more hard, owing to the interspersion of minute particles of quartz, being very similar to the stone with which the ancient Roman ways were paved, and which is by some called lava. Some of the ancient *basalts* therefore cannot be distinguished from *siderites*, as the ancients were not conversant in the minute discriminations of modern science: and some monuments which they would have called basalts, a modern mineralogist would rank among the black granites. But as the ancients cannot be our guides in mineralogy, a science to them

Ancient basalt.

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* Fossilia Ægyptiaca Musei Borgiani. *Velitris*, 1794, 4to. p. 7.

utterly unknown, it is sufficient to say, that the rocks which the acute Werner, and his disciples, have classed under HORNBLENDE, here appear under SIDERITE, and some of their TRAPS under BASALT; while the trap of the Swedes, with a fine grain, is here called BASALTIN. The difference indeed is rather in the transition; the chemical analysis of siderite and basalt being nearly the same.

SIDERITE.		BASALT.	
Silex	37	Silex	50
Argil	22	Argil	15
Magnesia	16	Magnesia	2
Lime	2	Lime	8
Oxyd of iron	23	Iron	25
	100		100

It scarcely needs to be observed, that in all substances the proportion of ingredients varies according to circumstances.

In general therefore where the substance has a crystallised and silky appearance, it must be classed among the siderites; but when it wears a dull or earthy aspect, it belongs to the basalts, though in the latter shining crystals of siderite may be interspersed.

When mica alone is found in a substance, it cannot alter the denomination, for, as Mr. Kirwan has observed, there is scarcely a mineral in which it may not be found. But the mixture of siderite with felspar deserves a distinct appellation. The term *grunstein* or *green stone*, used by Werner, has been deservedly ridiculed, as alike vague and barbarous. He borrowed it from the Swedes, whose grunstein was really green. It is further objectionable, as he extends it to green porphyry, and other mixtures of earthy trap or basaltin. As many new appellations are wanted, to distinguish with brevity and precision the different kinds of rocks, it is proposed to call this mixture WALLERITE, in honour of Wallerius, the great Swedish father of mineralogy. The other kinds of grunstein are arranged after basalt; as by their earthy texture they differ greatly from the former: nor can the black and green porphyry of the ancients, classed by Werner under this head, be considered as having any other basis than common trap.

Grunstein.

Wallerite.

STRUCTURE I. COMMON SIDERITE.

Aspect 1. Uniform. Black siderite of Egypt. This substance is more generally found mingled with granite; but *scarabæi* and other small sculptures sometimes occur in it, and sometimes in that ore of iron called hematites*.

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* See Wad, p. 8 and 32.

Black siderite from Mount Sinai. Given to the author by Roziere, a skilful mineralogist, who accompanied the French expedition.

Compact siderite, from the isle of Col, Scotland.

The same, from the iron-mines of Sweden.

The same, of a brownish and grey colour, from Finland.

Green siderite, from Sweden.

Saussure mentions, § 1824, beautiful beds of black siderite, in one of which an excavation had been made to extract crystal.

Aspect 2. Mingled. Black siderite, with mica, from Egypt.

The same, with olivine, from Egypt.

The same, with gold and silver, or with *electrum*, a natural mixture of these two metals, from Kongsberg in Norway.

Green siderite, with garnets, from Sweden.

The same, intermixed with iron ore, from Salzburg.

The same, with hard clay, from Vesuvius.

The same, with pyrites, from Arindal in Norway.

The same, from Salberg in Sweden.

The same, from the iron-mines of Dognaska, in the Bannat of Hungary.

The detached crystals of siderite, and what is called Labradore hornblende, or schillerspar, if it be not another substance, are properly topics of gemmology, or lithology, and not of petralogy, as they never occur in the form of rocks. It may be proper to observe, that siderite is called by many French writers *schorl en masse*, and sometimes *schorl spathique*.

The real grunstein of the Swedes is a mixture of siderite and mica, sometimes with particles of quartz*.

Fine grained siderite, with mica, from Upland.

The same, large grained, with quartz, from Smoland.

The same, with spots of steatite, from Taxas in Smoland.

STRUCTURE II. SCHISTOSE SIDERITE.

This substance, the *hornblende slate* of the Germans, is often found in gneiss, as already mentioned; but it is often joined with compact siderite; and, with a greater mixture of magnesia, passes into chlorite slate: for between siderite, chlorite, and actinote, there is a near connexion; whence Saussure argued that chlorite is merely the earth of green hornblende. Compact and slaty siderite also frequently occurs, in large masses, in common slate, a kindred rock.

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* Wall. i. 436. Whence it appears that it was also called *Binda* and *Jernbinda*: the *Saxum ferreum* of our author.

Aspect 1. Uniform. Schistose siderite, of a beautiful silky texture, from Kongsberg in Norway.

Schistose siderite, from Holyhead.

The same, delicately waved, from Norway and the *Highlands* of Scotland.

Aspect 2. Mingled. Schistose siderite, with garnets, from Kongsberg.

The same, with native gold and silver, from the same.

The same, with particles of quartz, from Saxony.

Schistose siderite in divergent rays, sometimes of a fascicular sometimes of a starry form, from the Alps, where it is often imbedded in granular felspar. This rock will seldom admit of a polish, otherwise it might rival the Miagite, the arborescent granitel found in the ruins of Rome, and other splendid and celebrated mixtures of felspar and siderite, which are here classed amongst the ANOMALOUS ROCKS.

Saussure describes different kinds of schistose siderite in the following terms:

"The schistus composed of hornblende and felspar is very common upon the banks of the Isere, and this is not extraordinary, as there are even entire mountains of it in Dauphiny, which I have myself seen. The famous silver mine of Challenches, into which I descended, is in a mountain of this kind. The varieties of this rock are extremely numerous; we find it with leaves singularly distorted, or bent in zigzag. It sometimes occurs with thick leaves, and at others as thin as paper. In some varieties, the leaves of pure and coloured hornblende, alternate with leaves of white and pure felspar; in others, these two substances are almost confounded; in others, in short, the leaves are interrupted either suddenly or by gradations. There are also frequently found knots or detached pieces of white felspar, confusedly crystallised, and often mixed with quartzose parts. It is curious to observe, when these knots are of irregular shapes, the exactness with which the schistose leaves follow all the convolutions of the knots, and form a kind of fortifications around them.

"The hornblende varies in its colour; sometimes black and brilliant, sometimes inclining to green, at others brown or grey; its form sometimes presents pretty regular crystals, especially in schisti, whose leaves are straight; and at other times thin plates, almost as brilliant as mica, without any appearance of a regular form. It is likewise more or less fusible under the blow-pipe.

"The felspar also varies by its white colour more or less pure, and inclining sometimes to a green or rosy hue; and by its form which, at one time, presents pretty regular rhomboidal laminæ, at others a crystallisation quite confused in small granular masses, like statuary marble. There is sometimes seen in the leaves, as in the knots, a mixture of a little quartz. The felspar which enters into the composition of this schistus is commonly of that kind which I have termed *feldspath sec*, or dry felspar; I have however seen but only one piece, of which the felspar was *gras*, or unctuous." § 1586.

He also mentions—

§ 2227. A green rock, which he would formerly have called *roche de corne*, but must now refer to the hornblende slate of Werner: and,

§ 1971. A gneiss, composed of laminar siderite and felspar, on the ascent of Mont Blanc.

§ 2271. A slate of fine scales of mica and hornblende, sometimes in level plates, sometimes undulated. It is of an olive-green colour, acts faintly upon the magnet, and makes a hasty effervescence with acids; a proof that it contains some calcareous particles.

§ 2131. Near Macugnaga, brilliant hornblende slate, in large redoubled layers, so as to form masses three or four inches in thickness, enchased in dull white quartz.

§ 1822. Beautiful rocks of granular felspar, with long irregular crystals of siderite, which sometimes assume the form of sheaves or diverging rays. The base of granular felspar has been mistaken for a sandstone.

§ 2144. Sheaves of black hornblende, two or three inches in diameter, forming a most beautiful effect on a white gneiss.

§ 164. Siderite, in the form of a sheaf, or rather fan, on granular quartz, or rather felspar.

§ 1954. Siderite mixed with calcareous particles, ramifying alternately with quartz.

STRUCTURE III. WALLERITE.

Wallerite.

This rock, as already mentioned, is one of the primitive grunsteins of Werner, but is here restricted to a mixture of crystalline siderite with felspar; the other primitive grunsteins being classed after the basalts, to which they more strictly belong.

Wallerite from Sweden, of black crystalline siderite mixed with felspar.

The same, greenish black, from Snowdon in Wales.

The same, from Mount Sinai.

MODE II. BASALT.

Characters. Texture coarse, generally mixed with grains of quartz or felspar; it has sometimes a crystalline appearance, but the crystals are minute, so that it appears earthy.

Hardness basaltic. Fracture rather even. Fragments rather sharp.

Weight siderose.

Lustre shining. Opake.

Colour iron grey, sometimes greenish.

This celebrated substance is one of the traps, or rather a *grunstein*, of the Swedes and Germans; and is by the Wernerian school considered as of three remote formations, the primitive, transitive; and stratiform, also called *floetz*, or *horizontal*. Formations.

Basalt proper. The basaltic monuments of the ancients are allowed by Dolomieu and Faujas, two chief supporters of the Volcanic system, not to be of a volcanic nature; and of course the restriction of the name to pretended compact lavas is not only objectionable, but highly absurd, as transferring a well-known term to a substance widely different. Compact lava is so uncommon a substance, that there was no specimen of it in the great collection of prince Biscari, at Catania;

while Gioeni and other writers on volcanoes say, that very seldom a piece without pores can be found, even of a few inches in diameter. A specimen of compact lava in the British Museum contains melted garnets; and is of such an appearance that no eye can confound it with basalt, even of the finest texture: yet Faujas, and other late French writers, persist in restricting the term basalt to a supposed lava, while they use the term trap for the real basalt of the ancients; which, even by their own volcanic theory, is of quite a different nature and origin*.

In his description of the Borgian monuments, as already mentioned, Wad found that those of basalt might chiefly be referred to siderite or hornblende: and it is remarkable that the word *basaltes*, according to Pliny, signified *iron* in the Ethiopic language, as *sideros* does in the Greek. The basalts of the ancients are often siderites, sometimes with veins or grains of felspar or quartz; sometimes with olivine: the only antique specimen in which leucite occurs having, as Wad observes, been sculptured at Rome.

Some small Egyptian monuments, however, Basaltin. occur in *fine basalt*, here called *basaltin:* to which last division the basalt or trap of the moderns, and pretended lava of the French mineralogists, properly belongs. For the basalt of Agricola, the trap of Wallerius and Werner, a substance abundant in the Faroe isles*, Sweden, Scotland, Ireland, Saxony, Auvergne, Sicily, &c. may also be traced among the Egyptian and other ancient monuments; and as Pliny informs us that the name of iron-stone was given on account of its colour and hardness, this appellation must have been yet more applicable to fine-grained trap than to siderite, which is of a looser grain and softer cohesion. And while the ancient denominations are so indistinct that they have included green fluor, and the fine green granite of Abyssinia, among the emeralds†, it is easily conceivable that the term basalt was extended to two or three distinct rocks, of a colour and hardness approaching to iron: but even the basaltin, or fine-grained basalt of the ancients, is frequently interspersed with minute grains of quartz or felspar; and monuments of what we would strictly call trap or basalt are comparatively rare. But as it is evident that the basalt of the ancients was more commonly of a coarse grain, and often intermixed with quartz or felspar; it has been thought proper, for the sake of precision, to confine the term to that substance; while the name basaltin is applied to the fine-grained basalt of the moderns, which frequently assumes the columnar form, in which shape also the former sometimes occurs. There is no doubt, for example, that some of the *whins* of the Scottish mineralogists, in which grains of quartz or felspar are mixed with trap, strictly and properly belong to the basalts of the ancients.

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* The name *basalt* seems subject to a singular fatality of abuse, the grave Wallerius having, with equal skill, degraded it to common *schorl!*

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* In the north of Europe. This spelling distinguishes them from Ferro, one of the Canaries.

† There seems little doubt that the pillars said to be of emerald were of this substance.

The dispute therefore concerning the Neptunian or the Volcanic origin of this substance must more aptly be considered as having no concern with the proper BASALT of the ancients, but with the modern basalt, here called *basaltin.* The author of this work is not attached to any theory, nor does he believe that the facts and observations are yet sufficiently numerous to afford even the semblance of a plausible concatenation; but he may be allowed to observe, that though volcanoes are often situated in basaltic countries, as they of course abound with iron, of itself inflammable, and yet more with sulphur, and probably forming the great source of volcanic fires; yet, as there is no proof of any volcano, however vast and powerful, as Etna, or some of those in the Andes, having in any ancient or modern eruption furnished basalt, either in columns or in strata, it would seem an infallible inference that this substance cannot be of volcanic origin*. The wide extent also of this substance, and the common situation of basaltic columns on the summits of hills, strongly militate against this idea. The same formation of basaltic columns resting sometimes on amorphous basalt, sometimes on indurated clay tinged with red ochre† of iron, is found to extend near thirty miles into Ireland from the Giants' Causy, and as far as the northern Faroe isles, a space of more than six degrees, or three hundred and sixty geographical miles; and, it is worth remarking, nearly in the same meridian. In like manner the basalt of Saxony might be said by a theorist to extend through Sweden, even to Spitzbergen; and it is observable that all the northern parts of Europe abound with iron; those of Asia are concealed by perpetual ice, snow, and marshes; while those of America seem chiefly to present copper. The basaltic columns of Germany, as is well known, are chiefly situated on the tops of hills; and, from Landt's recent interesting description of the Faroe isles, it appears that this phenomenon is there equally common. A magnificent example occurs in the isle of Osteroe.

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* None of the numerous hills around Etna is capped with basalt; nor have the isles ejected by submarine volcanoes presented that substance; so there is no proof of a subaqueous origin. The prisms on the shore around Etna are very rude, and unlike the beauty and exactness of basaltic columns.

† Does the red colour indicate heat, as yellow ochre thus assumes that tinge?

Basalt of Faroe.

"To the north of the village of Zellatræ there is a basaltic hill, which extends more than a mile northwards: properly speaking, it forms the bottom of two hills, which lie behind it, namely Halgafieldstinden and Rodefieldstinden, which are of considerable height, and about two miles distant from each other. The basaltic hill itself is about four hundred and twenty feet high, and consists of strata of pentagonal and octagonal basaltic columns, placed close to each other in a perpendicular direction, and in such a manner that the tops only of the farther columns are seen, while those in front exhibit their whole form, but appear to be different in length. These columns, which rest on a foundation of trap about three hundred feet in height, are the largest of the kind in the Faroe islands; for where the rock has been freed from mould, these colossal pillars may be seen with their lower ends standing on another species of stone, and rising to the height of above a hundred feet, all equal in size, being about six feet in diameter. Many of these huge columns, which have fallen down, are now lying at the bottom of the hill; one in particular, sixty feet in length, has been thrown across a deep gulley, with its ends resting on each side, so as to form a bridge over it[*]."

Of dubious origin.

It also appears from Dr. Richardson's recent observations[†], that the basalt in the north of Ireland occurs on the tops of hills, at a great distance, while the intervening space has been, as it were, scooped out by some exterior agency, with which we are at present totally unacquainted. But whether some comet has approached the earth, or some small planet, like one of those recently discovered, has fallen into it, and occasioned appearances altogether inexplicable upon our small scale of observation, most probably may ever remain a matter of theory[‡]: and in natural, as well as in civil history, there are many objects of which the best judges choose to remain in what Mr. Gibbon emphatically calls A LEARNED IGNORANCE. Nor must it be forgotten, that masses of sandstone and limestone are, in like manner, found upon the summits of hills, quite detached from the original beds to which they would seem to belong by the identity of their substance. From these remarks it must appear to every impartial mind, that the phenomena of basalt are on too vast a scale, and of an appearance too uncommon, to be produced even by a chain of volcanoes, of which the Andes present most extensive examples; so that to confine the appellation of basalt, with the French mineralogists, exclusively to a pretended compact lava, would be a mere assumption, alike foreign to ancient erudition, and the precision of modern science.

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[*] Landt, 39.

[†] Ph. Tr. 1808.

[‡] Dolomieu, *J. de Ph.* 1791, p. 385, thinks that an exterior shock has broken the crust of the globe, and raised parts on others. The like ideas may be inferred from the REFOULEMENT of Saussure.

STRUCTURE I. AMORPHOUS BASALT*.

Egyptian.

Basalt of a greyish black, with very small grains of white quartz, and spots of iron ochre, from Egypt†.

Basalt of a blueish grey, glimmering lustre, and fasciculated fracture, from the same.

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* It is always of a mingled aspect.

† It is only to be inferred that the Egyptian basalts do not belong to the columnar. Ferber erroneously says, that Strabo mentions the Ethiopic basalt as columnar. That author, lib. 17, describes a pyramid, partly built of basalt, from the extreme mountains of Abyssinia.

With a mixture of amorphous black siderite, and minute grains of white quartz, from the same.

The same interspersed with transparent felspar, which becomes greenish from the mixture, from the same.

Greyish black basalt, interspersed with black siderite, partly amorphous partly crystallised, and with greyish white felspar.

The same, with black siderite, and small grains of yellowish green olivine.

The same, with black siderite, partly amorphous partly crystallised, olive-green olivine, and scattered particles of black mica.

The same, superficially spotted with reddish brown, probably from the decomposition of the iron.

Greyish black basalt, interspersed with crystallised siderite, with small crystals of olivine in square prisms, of which some being decomposed, the surface becomes porous, while the interior is completely dense*.

Such is the catalogue of ancient basalts observed by Wad in the Borgian museum, there not being even one example of basaltin, though it certainly occurs in small Egyptian monuments; and the author saw at Paris the statues of a king and queen sitting, in one piece about nine inches in height, the back and sides being covered with hieroglyphics. He also saw in the same collection small fragments of green basaltin, from Egypt.

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* Such basalts have deceived the volcanists.

Patrin gives the following list of ancient basalts*.

Oriental.

"Oriental basalt of a blackish grey, of a fine grain, mixed with white scales of felspar, and little veins of quartz. This is the kind most commonly observed in ancient monuments.

"Oriental black basalt. It is mixed with grains of quartz, with small crystals of felspar, and with spangles of mica; these ingredients are not combined as in granite, but interspersed in the black base of trap. The Isis, which is in the court of the Capitol, is of this stone.

"Oriental black basalt, radiated with veins of red granite, in small grains. The two sphinxes, which are at the foot of the great stair-case of the Capitol, are of this basalt.

"Oriental black basalt, with green spots of siderite. It is called at Rome Egyptian stone, or nephritic stone.

"Oriental green basalt. It is of the same base as green porphyry: the only difference is, that the substance of felspar is equally interspersed in it, and is not united in crystals. This base is homogeneous, very compact, and very hard. Fine statues of it are seen in the Capitol, and in the Villa Albani.

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* i. 127. The French authors rarely quote their authorities; but Patrin has borrowed his examples from Ferber's Travels in Italy.

"Oriental green basalt, with white specks. It is the same as the preceding, in which the felspar is united in small crystals: it is named speckled basalt, and is very rare. There are two pillars of it at *Rome*, in the church of St. Pudentiana.

"Dolomieu says, that there is such a vast number of Egyptian monuments in the Borgian Museum at Veletri, that they are almost sufficient to constitute the whole Egyptian Lithology: many are formed of stones which have qualities attributed to basalts; not one is volcanic."

In passing to the modern basalts, it must be premised that the trap of Wallerius, which he describes as being of an impalpably fine grain, belongs solely to the basalt of the moderns, here called basaltin from that circumstance. But the basaltic granite of this venerable author * certainly includes some of the basalts of the ancients; as that of an iron-colour, mixed with the ore of that metal and quartz, which is found at Norberg, in Westmania. His *saxum ferreum*, composed of various mixtures of siderite, mica, basalt, and quartz, may also sometimes be referred to this Mode*.

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* i. 422.

Basalt, with mica, from Upland in Sweden.

Green basalt, with black mica, and sometimes a mixture of quartz, from Westmania.

The basaltin of Kirwan is merely crystallised hornblende, or siderite; but the basaltin of Baron de Born is often the real basalt of the ancients, while his basalt is here called basaltin. He mentions that kind, mingled with green siderite and olivine, from Bohemia; and that mingled with brown mica, from the same country. In his treatise on traps, Faujas confines himself to the basaltins, or fine-grained basalts; he mentions a trap, sometimes black sometimes green, with grains of semitransparent quartz, from Scotland and Provence, which may probably be classed among the ancient basalts†. The pillars of grunstein, which compose the innermost circle at Stonehenge, may also belong to this division‡.

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* i. 437.

† Launay, *Essai sur les Roches*, 64, mentions a mixture of trap and felspar, from the isle of Bornholm, Denmark.

‡ Townson's Tracts; whence may also be added the *whin* of Salisbury Craigs, near Edinburgh, containing siderite and felspar.

STRUCTURE II. COLUMNAR.

The following passage of Strabo has been thought to imply columnar basalt:

"We went to Philoe from Syene in a carriage, through a level plain, the space of a hundred stadia. Along almost all the route were to be seen, on both sides, in many places, as it were *terms*[*], of a hard, round, and polished stone, almost spherical, and of which mortars are commonly made, placed upon a larger stone, and surmounted by another. Some even lay apart; the largest being not less than twelve feet in diameter, and the others about half as large[†]."

Several authors have inferred from this passage that Strabo means to speak of columnar basalt, but he would rather seem to imply a work of art, a magnificent avenue from Ethiopia into Egypt. No basaltic columns have been observed twelve feet in diameter; and even if the passage be corrupt, and twelve feet in height be intended, or perhaps two feet in diameter, it would still remain so obscure, that it would be adventurous to build any solid argument upon such an uncertain foundation. It is singular that Denon, who has given such a minute and interesting account of the isle of Philoe, should have taken no notice of these remarkable monuments. He speaks indeed of large blocks of stone covered with hieroglyphics, but mentions nothing but granite in that quarter; and basalt could scarcely have escaped the attention of a French traveller.

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[*] The little hermetic columns at Athens.

[†] Strabo, lib. 17.

The columnar form is far more commonly assumed by the basaltin, than by the real ancient basalt: yet it is found even among other substances.

"Columns of porphyry are not rare; and, among other places, are found near Dresden, several feet in length, and not more than two inches in diameter*. Columns of petrosilex compose a large portion of a mountain near Conistone lake. Very perfect quadrangular prisms of argillaceous schistus are found near Llanurst. Rubble slate assumes the columnar form at Barmouth. The limestone near Cyfartha, in Glamorganshire, is divided into very regular acute rhomboidal prisms: even the sandstone of the same district is not unfrequently columnar; and one of the beds of gypsum at Montmartre is distinctly divided into pretty regular columns. Sandstone, clay, argillaceous iron ore, and many other substances, become prismatic by torrefaction; and the prisms of starch formed in drying, have often been considered as illustrative of basaltic formations*."

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* Strange's *granitic* columns, near Verona, are *porphyritic*, with a paste or basis. Spallanzani.

Among the numerous examples of columnar basaltin, it is well known that they often occur of a coarser grain, and mixed with felspar and siderite, thus strictly belonging to the basalt of the ancients. The columns in the north of Italy, supposed to be volcanic, seem chiefly to consist of this substance. I do not however find that the German mineralogists mention their *grunstein*, as occurring in a columnar form, though Daubuisson has evinced that grunstein and basalt are the same substance. The analysis of Dr. Kennedy is as follows:

	BASALT.	GRUNSTEIN.
Silex	46	46
Argil	16	19
Lime	9	8
Oxyd of iron . . .	16	17
Water and volatile matter	5	4
Soda	4	3½
Muriatic acid . . .	1	1
Loss	3	1½
	100	100

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* Watt, Ph. Tr. 1804.

It would indeed be a singularity that, while basaltin occurs so often in a columnar form, a substance composed of the same ingredients should never assume that appearance. Yet perhaps the columnar form of basaltin may itself be partly owing to the impalpable fineness of the ingredients allowing an exact scission, or crystallisation, which coarser materials would not admit; as crystals are generally composed of finer ingredients than amorphous substances.

MODE III. BASALTIN.

Characters.

Texture finely and almost impalpably granular, sometimes vesicular; on a large scale stratified, rising like successive *steps*, whence the Swedish name *trap*. It sometimes presents distinct concretions, of a finer or of a coarser grain. It seems to split in rhomboids, while the columnar sometimes lapses into globular forms *.

Hardness basaltic, or between marble and felspar, about 800 of the scale of Quist. Fracture sometimes even, sometimes conchoidal. Fragments amorphous; not very sharp.

Weight siderose.

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* Mr. Watt, Ph. Tr. 1804, observes, that melted basalt passes into globules, before it assumes the compact texture.

Lustre dull, except when mixed with siderite. Opake.

Colour greyish black, greenish, rarely brown or reddish.

This is the basalt, or fine-grained trap, of the moderns. Karsten has supposed that even the finest basalt is a mixture of impalpable grains of siderite and felspar, or quartz; which would indeed appear to be confirmed by the identity of the chemical constituents. Faujas also argues in favour of his volcanic theory of basalt, that trap, which he allows not to be of a volcanic nature, is merely a granite of a very fine grain. This idea partly rose from the confused and lax manner in which the term granite has been hitherto used; and partly from his theory that real basalt is always a lava. But in this way all the mixed rocks might be classed under granites; for there is scarcely a mixture which has not been arranged under that head by some mineralogist, as the reader may perceive from the edition of Linnæus by Gmelin. It is true that a mixture of siderite felspar and quartz would form a genuine granite, and that some of the basalts of the ancients might be classed, as Wad has observed, among the granitels: but where the siderite so preponderates as to give a great prevalence to its colour; and especially where the particles are earthy instead of being crystallised, as in granite, where the silicious part superabounds; a wide difference has always been allowed. A variation of the same ingredients will indeed ever form one of the chief distinctions in mineralogy; for it must be repeated, that it is not the *ingredients*, but the *mode* of their combination, which forms the chief distinction: diamond being akin to coal; sapphire only consisting of clay and rust; and, among the argillaceous and magnesian rocks, silex is commonly the predominating ingredient, but still the argil and magnesia give the character and name.

But let us listen to the great master of petralogy on this interesting topic.

Saussure's opinion.

"I call *trap*, a rock composed of small grains of different qualities, confusedly crystallised, inclosed in a cement, and sometimes also united together without any distinct cement; and with no perceptible regular crystals, except rarely and accidentally.

"This definition connects traps with granites and porphyries; but M. Dolomieu has made it very evident that this approximation already exists in nature. He observed at Rome, in the masses of granite and porphyry selected and worked by the ancients, as we observe it in our Alps, and in the blocks that are detached from them, varied transitions between these different kinds.

"I think besides that, in the nomenclature of mineralogy, it must be regarded as a principle, to determine the kinds and species, from individuals whose characters are the most striking; and to mark the transitions of doubtful and ill-defined substances: for the principle established in botany, of considering as belonging to the same species, individuals between which we observe intermediate shades, cannot be admitted in mineralogy, without reducing all known fossils to one and a single species. Indeed there is none that may not be departed from, to make the tour of the whole chain of those which have already been determined, by almost insensible shades; and the more we shall study mineralogy, the more this truth will become obvious, by the number of varieties and shades that we shall discover.

"I therefore say, that when two fossils present remarkable differences, we must not refrain from distinguishing them, and giving them different names, under the pretext that we have found intermediate varieties which seem to connect them, by appearing to belong equally to the one and the other; without which, I repeat, that we shall no longer distinguish genera nor species; there would be but one and the same name for all the mineral kingdom. Thus I distinguish granite from porphyry, porphyry from trap, this from petrosilex, *roches de corne*, and argillolites, because the well-characterised individuals of these different kinds are evidently distinct; and I do not embarrass myself because there are transitions or intermediate varieties, which I do not exactly know to which kind I ought to refer.

"I have in this only to regret a deviation from the acceptation that M. Dolomieu has given to the name of *trap*, in the excellent work he published, *Journal de Physique*, An 2. Part I. page 257. He had given this name to the *corneus trapezius* of Wallerius, which is a simple stone of the genus *cornéennes*, with a fine and compact fracture. But I have already observed in another place, that the genus of simple *cornéennes* does not require this subdivision, whilst the class of composites or rocks appears incapable of avoiding it; and of them the celebrated Werner has even formed such a class, where, under the head of *trapp formazion*, he includes *grunstein*, the *amygdaloïde*, the *porphyrschiefer*, and *bazalt*.

"I shall also observe, that the Swedes give the name of *trap*, not only to a simple and compact *cornéenne*, but also to composite rocks, or to rocks of which this cornéenne forms the cement; it is the *saxum trápezium*, Wall. Sp. 220. We may also see the description that M. Nose gives of 31 species of traps which he received from Sweden, *Beyträge*, p. 401. *seq.* M. de Faujas, in his little treatise upon traps, equally gives to this word a very wide acceptation; but it does not seem conformable to the laws of a good nomenclature, to give the same name to substances which belong to different classes.

" It is according to these principles that I determined to confine the name of trap to a composite rock, or to the rock of which I have given a definition at the beginning of this paragraph.

" 1946. The traps forming the cement of different variolites of the river Emme, vary in their colours and nature. We see some of them grey, others approaching to green, and others to a violet colour; they are more or less hard, some containing only in their glands free calcareous parts; others contain in their paste some which become friable after having remained in the nitrous acid. Even the cement which unites the grains or small crystals of these traps is for the most part clay, hardened into argillolite, more or less ferruginous. The little grains, I speak of those which compose the substance of traps, and not of the large grains or glands which form amygdaloids, these little grains, I say, are of quartz, felspar, sometimes of hornblende, and of that substance I have called granular chusite, § 1944*."

Volcanoes.

According to the present classification, genuine basalt, that of the ancients, must be omitted in the dispute between the Neptunists and Volcanists, which only regards basaltin. The common trap of the Swedes and Germans is always a basaltin; and when stratified is allowed even by Faujas not to be volcanic. The contest therefore chiefly relates to the columnar basaltin, which the French mineralogists infer to be always of a volcanic origin; while, as already observed, it seems rather to arise from a phenomenon still more grand and rare. The great chain of volcanoes in the Andes is chiefly argillaceous, or clay porphyry; and their most dangerous ejections are torrents of mud. In New Spain, where the mountains are chiefly of clay-slate, a volcano suddenly burst out in the vale of Jorullo, 1759; when, according to Humboldt, who saw it in 1803, a basaltic cone appeared above ground, of 1400 feet in height: but this cone seems rather to have been developed than elevated by the new volcano, as it could scarcely be formed from fluid lava, which would be contradictory to the common laws of hydrostatics. The accounts of the volcanoes in the Andes are far from being complete; but there seems to be little or no mention of basalt, and no hint of basaltic columns; which, if they were volcanic, would be truly surprising in a chain which extends more than three thousand miles, and contains about a hundred active volcanoes.

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* Sauss. vii. 203. For the chusite of Saussure, see his Journey to the extinct volcanoes of Brisgaw, *Journ. de Ph.* 1794, p. 325.

See also his account of *pierres de corne*, § 95: most of them may be scratched by the nail. He says, § 103, that trap is a compact *pierre de corne*, which not being a production of fire, is very different from basalt. In § 1525, Saussure doubts if the basaltin of the extinct volcano of Beaulieu be volcanic.

But as the presence of iron seems necessary to volcanic inflammation, and the same metal forms the ruling ingredient of basalt, it is no wonder that this coincidence should have occasioned a confusion of ideas. Around the grand volcano of the isle of Bourbon, there are basaltic rocks; and where the basaltin contains sulphur, it may be presumed to be a compact lava; but here are no ranges of those grand basaltic columns which distinguish Faroe, or Staffa. If we return to Europe, the grand volcano of Etna has probably been in a state of conflagration for 2500 years, and the circumference is computed to extend to one hundred and thirty miles; yet, among the numerous hills which surround this sublime volcano, there is none capped with basaltic columns; and its lavas, after such numerous ejections, do not seem even accidentally to have assumed those elegant and precise forms*. Dolomieu, and other prejudiced Volcanists, have indeed observed instances of the lava divided into rude prisms; but where is the representation of any Giants' Causey in Sicily? Where the base of Etna reaches the sea on the east the shore is volcanic, or at least supposed to be so, for the space of twenty-three miles; and for the first seven or eight miles after leaving Catania, Spallanzani indeed observed some prisms, more or less characterised; but the two other thirds of this shore, though equally consisting of lava, only present irregular fissures. It is presumed that even the former bear but a slight resemblance to the beautiful articulated columns of Staffa, or the Giants' Causey, especially as figured by Da Costa and Pictet. It is also to be questioned whether these columns of Etna be

* Von Troil has observed, that basaltic columns are common in Iceland; but the people suppose their ranges the work of giants, while, if they originated from the volcanoes, the circumstance would strike the most common observer. They sometimes appear among lava, sometimes among tufa; that is, they are preexistent to either.

not composed of porous lava, as Dolomieu allows that some are, while others, as he says, are compact, because the water stops the internal effervescence; and whether, if the observers had seen the elegant articulated columns of the north of Europe, they would not have rejected the comparison *? But as Sicily may be said to be in our possession, and the interesting work of Dolomieu has not been translated into English, it may not be irrelevant to present an extract, that future observers may decide whether the appearances be caused by the eruptions, or be antecedent to them.

Basaltin of Etna.

" As basaltic columns rarely appear in cabinets, and it is more interesting to see them on the spot, that their groups may be the better followed, I shall point out those parts of Etna where the most curious phenomena of this kind may be observed.

" In the second of the Cyclopic isles, of which the form is that of a long pyramid, immense prismatic columns, perpendicular, articulated, and for the most part hexagonal, appear; the diameter of which is from two to three feet.

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* I have seen, in the beautiful collection of M. Patrin, at Paris, berils articulated in the same manner with basaltin: but no one has supposed that berils are produced by fire.

bastions. The columns reunited by their summits, as into one head, enlarge according to their length.

"Scattered prisms and walls of prismatic lavas may also be found in many other places; forming, as I have already mentioned, a kind of belt around the skirts of Etna. Don Joseph Gioeni, whom I have formerly celebrated, is occupied with an elaborate description of the prismatic lavas of the volcano; and he will add prints which can alone express the variety of their forms, and the manner in which they are grouped*."

If these representations be exact, they would certainly induce us to believe that prismatic basaltin is the product of volcanic fires; and an admirer of nature would willingly embrace a new and important discovery, which would afford greater variety to his views, and more striking topics for his contemplation. With regard to the British dominions, in particular, a volcano, even extinct, might be regarded as a grand and curious acquisition. The great number of volcanoes which exist, or have existed, in Iceland, the southern skirts of which can alone be said to be known to naturalists, might well authorise us to believe that a chain of volcanoes may have existed in a tract of country, or isles, between the north of Ireland and Faroe, and which have been submerged, the foundations being destroyed by the violence of their own conflagrations, and the fury of the Atlantic ocean. There are indeed, according to Landt, evidences of a vitreous lava in one of the isles of Faroe; and my intelligent friend Mr. Browne, who has penetrated so far into Africa, and has pervaded many parts of Asia and Europe, was convinced that he observed a wall of porous lava near Belfast; but still there is no appearance of any craters. Perhaps a disciple of Dolomieu, certainly a great and respected name, "*clarum et venerabile nomen*," would be contented with one enormous volcano between the north of Ireland and Staffa, and another among the Faroe isles; for the exterior chain of the Hebudes is granitic, as are most of the Shetland islands; while the Orkneys consist of argillaceous sand-stone; and none of them can, on any theory, be said to present volcanic appearances.

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* Dolomieu, Etna, p. 455. It must not however be forgotten that, p. 192, he allows that all these columns present small pores, visible by a lens; nay, p. 180, he regards all lavas as compact which contain spaces of some inches without pores. But he might say, as compactness is owing to refrigeration, that, in the cold and moist regions of the north, lavas are more compact.

However this be, as the genuine basalt, that of the ancients, is allowed on all hands not to be of a volcanic nature, the distinct name basaltin becomes the more necessary, in order to discriminate a wholly different substance, the origin of which is still liable to contestation.

Concerning basaltin, by many called compact lava, further observations will be found in discussing the Volcanic Rocks. The testimony of Daubuisson, concerning the volcanic origin of this substance, is too remarkable to be omitted, as in his able treatise on basalt he has strongly enforced the contrary opinion, embraced while he was at Freyberg, and enveloped in the vortex of Werner. This change of his Neptunean ideas occurred after his visit to Auvergne, a country which presents many extinct volcanoes, as all who have seen it or its products must confess; this curious fact being only denied by those who are lost in the mist of prejudice, and who in fact ruin their own system, by pushing it so far as to maintain tenets palpably absurd, and contradictory to the common sense of mankind; such as, for example, that pumice itself is of an aqueous origin! The following abstract of Daubuisson's remarks on Auvergne is given in the *Journal de Physique**.

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* 1804.

"After having given a preliminary idea of the topographical position of Auvergne, and the mineralogical structure of this country, M. Daubuisson has successively and in detail described the volcanoes and basalts of the country of Puy de Dome, Mont Dor*, and of Cantal, he concludes his memoir by a general review of his observations. We shall here give an extract from this latter part.

Daubuisson's opinion.

"Auvergne (Departments of the Puy de Dome and of Cantal) is in the middle of that great slope, or inclined plane, whose bottom lies towards the center of France, and which terminates in the upland that directs the course of the Rhone to the westward. The primitive soil (anterior to the volcanoes) is of granite, covered in some places with a marly limestone. The valleys excavated in this soil render the country unequal, and give it a mountainous appearance, although there are in fact only excrescences or volcanic mountains, which rise above the general plane of the slope.

"Nearly all this soil has been covered with volcanic productions: they are of three kinds, and their formation seems to date from three distinct epochs. The most recent and least

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[*] This is the proper spelling, derived from the river Dor, which, joining the Dogne, forms the Dordogne. See Le Grand.

numerous are currents of lava, which lead to craters still existing; the second are masses or tables of basalt, separated by rifts or valleys; the third consists of mountains whose mass is a kind of volcanic porphyry.

" 1st. *Lava in form of currents.* There are in Auvergne near a hundred conical, isolated mountains, from 200 to 400 yards in height, formed of heaps of scoriæ, fragments of lava and of lapillo: their summit often presents a hollow in the form of a cup or crater: they rest immediately on granite. From the bottom of several of them currents are observed to run of lava of a basaltic nature, that is of a greyish black, with a fine compact grain: this lava contains grains and crystals of peridot (olivine), augite, felspar, &c. The superficies is blistered and studded with asperities, which sometimes attain and even surpass a yard in height: the interior is more compact, and less porous, as you arrive nearer to the bottom. The currents are spread in the adjacent plain; they have sometimes reached the bottom of certain valleys, and have followed their course for a distance of three or four leagues; in advancing progressively they always incline to points lower and lower; they follow the inequalities of the soil; they separate on meeting with any obstructing eminences in their passage. In fact, like the courses of fluid matter, they have been subservient to all the laws of hydrodynamics. The history of these currents of lava is complete, and there is nothing left to the imagination to supply. We behold the orifice from whence they issued, the course they pursued, the country they occupy, &c.

"They flowed upon granite: their substance then was either in or under that rock; now these lavas contain from 15 to 20 per cent. of iron; the granite possesses scarcely any; they do not therefore consist of granite, fused and wrought by volcanic agents: we must therefore, with Dolomieu, seek under this rock, for the matter which has yielded this substance; but here we can only form conjectures. The cause which may have developed this subterranean fire, the combustible matter which may have maintained it, are entirely unknown to us. It is not coal, or bituminous matter, for they are only found in secondary regions, and never either in or under granite: it does not consist in pyrites, because pyrites, alone and enclosed in the bosom of the earth, never decompose, and generate no heat. As for the period when these lavas flowed, although anterior to the history or tradition of mankind, it is nevertheless very recent when compared with those vast degradations which the surface of the globe presents: it is posterior to the entire excavation of the valleys, since it occupies their bottoms.

"2d. *Basalts.* The volcanic productions of the second kind, are basalts, which, under the form of sheets, tables, peaks, cover the elevated parts of the ancient soil, or constitute the summit of some mountains and isolated eminences; they are also observed on almost all the skirts of Mont Dor and Cantal; they are evidently only the remains and patches of different currents, which have spread over the country; they present the same mineralogical characters as the basalts of other countries, Saxony, &c.; they contain the same substances; they equally incline to a prismatic division; they cover without distinction all kinds of rocks, and are never covered by them, &c.

"A volcanic origin cannot be denied to these basalts. The perfect resemblance between their paste and that of some parts of currents of lava which are found in the neighbourhood, and which have come from a crater still existing, is already a very strong presumption; but they present other infallible marks of this origin. 1. In following step by step certain masses of basalt which are near Mont Dor and Cantal, and supplying by the imagination what has visibly been taken away; you arrive at the sides of those two enormous volcanic mountains, and you come to masses of scoriæ or of blistered rocks, where, beyond doubt, we are near the source of the current; all the basalts which have been followed upwards, made part of that current. 2. A great number of those large basaltic platforms which cover isolated mountains, display on their surface blisters, spongy scoriæ, or drosses, like those which are observed on the best preserved lavas; nor can we refuse them a similar origin. Some others of these platforms repose on volcanic ashes. 3. Some isolated eminences present, it is true, summits of black basalt, compact, prismatic, destitute of those unequivocal signs of the action of fire which are seen elsewhere; but the greatest part of them stands by the side of those platforms with scoriated surfaces of which we have just spoken: they once formed with them a continued whole, and have evidently only been divided from them by the excavation of the valleys and ravines which now separate them. They cannot have had a different origin; the corrosive action of time and the elements must have destroyed the scorified bark; only the compact nucleus would remain, deprived of the marks of the action of fire, as are the interior parts of the greater portion of lavas in currents. Thus all the basalts of Auvergne present proofs, either direct or indirect, of a volcanic origin; though the degradation of the soil, the dismemberment that the currents have suffered, no longer permit us to retrace the crater from whence they flowed, nor to see the number, form, or extent, of the different currents: the only positive thing we can say in regard to them is, that their existence is anterior to the excavation of the valleys.

"3. *Porphyroid Masses.* The third species of volcanic productions of Auvergne is quite of a peculiar nature; they are grey stony masses, of a porphyritic structure; they form eight or ten distinct mountains: the most considerable are Cantal, whose diameter at the base may be about nine or ten leagues, and 900 or 1000 yards high, above its bottom; the Mont Dor, whose base is five or six leagues, and its height from 1000 to 1100 yards; the Puy de Dome, whose base is half a league in diameter, and 600 yards high: the other mountains are still less. The two first are vast masses, torn and irregularly cut by the action of the waters. The substance of which they are all composed is grey, often approaching to black, sometimes to green; its fracture dull and earthy, with coarser or finer grains; it has little hardness, and easily decomposes; its weight is about twice and a half greater than that of water; it melts easily under the blowpipe into white amel*, and seems to be composed of the same elements as felspar, but confusedly united; it contains a great quantity of crystals of felspar, some acicular crystals of hornblende, and even some spangles of mica. The klingstein-porphyr of the Germans†, which is found in considerable quantity at Mont Dor and Cantal, seems to be only a remarkable variety.

"These porphyroid masses so nearly resemble certain productions in the humid way, that it required nothing less than their extraordinary position, their situation in the midst of volcanoes, some unequivocal marks of the action of fire, their passage direct or indirect to basalt, and above all the volcanic scoriæ imbedded in their mass, to prove that they are foreign and posterior to the productions in the humid way, and that they owe their existence to the volcanoes.

"Nothing positive can be said as to the manner in which they have been produced, and arrived at their present position. No where is there observed any crater from which they could have issued, nor distinct currents by which they might be traced to their origin. It might be thought that they consist of melted granite, wrought and ejected by volcanic agents. The homogenity of their paste shows how complete the fusion or igneous dissolution has been, and scarcely permits one to believe that the number of crystals of felspar which they contain, should have pre-existed the fusion, and withstood it. The form of these crystals, their laminar structure perfectly preserved, their transparency, their facility of melting, their manner of *being* in these vast masses, and in short their analogy of composition with the paste which surrounds them, leads one to believe that they were formed during their igneous fluidity, by an approximation of their integrant parts, which were able to obey the laws of their affinity. These porphyroids are the most ancient of all the volcanic productions of Auvergne: they are covered with basalt, and contain veins of that substance.

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* See Johnson. Enamel is properly the application of the amel to another substance.

† Klaproth procured 8 per cent. of soda from that of Bohemia, and Mr. Bergman 6 from that of Mont Dor.

"However different these productions may be, however distant the various periods of their formation, they do not seem the less united in a certain degree, and form, in some sort, an identic system. Cantal, Mont Dor, Puy de Dome, &c. the most ancient of the volcanic masses, are in a direct line, running nearly from south to north. Almost all the basalts of these regions, that may be, in some manner, retraced to their origin, seem to have taken their direction in this same line. It is also in this direction, and among the ancient products, that the greater part of the craters have opened, whose vestiges are still visible. When at two leagues to the westward of Clermont, we see near sixty volcanic mountains, ranged in a straight line, one can scarcely believe it to be the effect of chance. A cause has certainly existed which has produced this effect: perhaps there was under-ground, and in this direction, as it were a vein of matter which contained the germ of volcanic fire, or which was of a nature to maintain it; the cause always existing, its effect might have been renewed at different periods."

These observations are no doubt cogent, and worthy of the acknowledged ability of the author. But in the spirit of perfect candour when treating a subject where it is difficult, after every allowance for the weakness of the human mind, even to suppose that prejudices should exist, Brochant's able abstract of the arguments for and against the volcanic origin of basaltin, shall here be subjoined, as the author thinks it a meritorious service to the science, to lay before the

English reader interesting extracts from such works in the foreign languages, as, from their very nature, can scarcely be expected ever to be known to him by translation.

Brochant's statement.

"It has already been said in the Introduction, p. 68, that mountains of secondary trap, and chiefly the basalts, were looked upon by some mineralogists as produced by volcanic fires, while Mr. Werner, and almost all the learned men of Germany, are of opinion, that they have been formed, like other rocks, by the waters which inundated the surface of the globe.

"The former ground their opinion on the following reasons.

"1. In the masses produced by volcanoes which have burnt in our time, are found prismatic basalts, and other rocks which resemble trap, and which nevertheless bear no character of fusion, and which only the locality and position indicate as volcanic.

"2. It is an error to believe that all the masses ejected by volcanoes must be vitrified substances; such are on the contrary very rare.

"3. Neither is the black colour essential to volcanic products: there are some grey, others brown, and even white.

"4. Many observations have proved, that the fire of volcanoes is very inferior to that of our furnaces; therefore it is not surprising that basalts may be changed by an artificial fusion; and it is no reason for believing that they have not before undergone the action of volcanic fires.

"5. Even supposing that volcanic fire possesses a great heat, it is known, by the beautiful experiments, made in England by sir James Hall, comparatively on the whinstone*, and on the lavas of Vesuvius, that a contexture and aspect may be given to a rocky mass, melted and cooled, which shall have the characters of glass or stone, according as the cooling is quicker or slower. These experiments having been repeated on several kinds of whinstone, there has always been obtained by a gentle cooling, a stony mass, compact, dull, exactly similar to the whinstone employed; and on the contrary, a vitreous mass was obtained by a rapid cooling. The same essays made on the substance of bottle glass, gave the same results.

"We see then that the absence of scoriæ and vitrifications is not a reason for denying the volcanic origin of basalt; besides, it is a known fact that burning volcanoes have produced it.

"* The whinstone of the English is generally a secondary trap; but among several specimens that I have seen given under that name, some resembled basalt, others grunstein; others in fine had the structure of amygdalite."

" 6. But without mentioning basalts, which have so many volcanic characters, a great analogy is found between secondary mandelstein and porous lavas; between the clay of trap mountains and the products of muddy eruptions; between basaltic tufa and volcanic tufa; and almost all minerals which are found scattered in volcanic masses, are found in trap mountains, &c.

" 7. The position of secondary traps, which lie over all secondary rocks, while the hardness, compactness, and other characters of many among them, such as grunstein, basalt, and others, are so different from those of the secondary rocks on which they lie. That kind of dryness to the feel which they present, and which is characteristic of volcanic productions in general, all these approximations will not permit us to acknowledge that basalts have had the same origin as all secondary rocks.

" 8. It has been objected that in basaltic countries basalt is found on almost all the summits, and that such would not be the case if basalts were lavas: this might be true if these lavas proceeded from a recent deposition; but on the contrary this deposit seems very ancient, and has undergone many changes. M. Reuss himself observed in Bohemia, that the basaltic summits he there met with, seem to be the remains of a vast bed of decayed basalt.

"9. In short, the conical form of trap mountains, and above all those of basalt, has the most perfect resemblance to that of volcanic mountains; and it is this resemblance which gave the first idea of attributing a volcanic origin to basalt.

"The advocates for the formation by the humid way, or the Neptunists, on their part support their opinions by many observations, of which these are the principal:

"1. It is true basalts are found among products of burning volcanoes, but they are extremely rare, and modern eruptions have not produced any.

"2. Whatever origin may be attributed to the division in prisms, tables, &c. it is not peculiar to trap rocks: there are gypsums, marls, sand-stones, which frequently offer this structure. Thus then this division in prisms, very rare among real volcanic products, on the contrary exists in many stratified rocks.

"3. Basalts often repose immediately on coal, as at Meissner, near Cassel: now, if this basalt was volcanic, it must necessarily have produced the combustion of these beds of coal.

"4. The remains of vegetables and animals, which are found in some trap rocks, could not in like manner have resisted the volcanic heat without being destroyed.

" It is the same with many minerals which are very fusible, and which are there met with: indeed, some are also found in volcanic rocks, but these instances are rare, and cannot serve as a basis to a general rule.

" 5. Cavities filled with water, such as enhydritic agates found near Vicenza, in Italy, in secondary trap mountains, entirely destroy all supposition of a volcanic origin *.

" 6. There are not observed in trap rocks either that black colour, or those indications of vitrifaction, that are apparent, at least in certain portions, of the products of burning volcanoes: real craters have never been observed. All those which have been cited were hollows, chasms filled with water, so common in some mountains.

" 7. Mandelstein has certainly some resemblance to porous lava; but there are mandelsteins evidently not volcanic. Besides, the cavities of the mandelstein of trap mountains contain very different minerals, and which could

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" * The Vulcanists answer that these agates have a latter origin from infiltration."

not have undergone the action of fire without being changed*.

"8. It is true, that according to the experiments of sir James Hall, and some late observations made upon burning volcanoes, it is known that rocky substances may, after fusion, reassume their stony character; but when this takes place in burning volcanoes, there are always found in the vicinity substances which have not experienced this effect, and which on the contrary are scorified or vitrified; which denotes the action of fire.

"9. In different countries, and especially in Bohemia and the Vicentine, beds of basalt have been observed, which alternate with grit, or stratiform limestone: does not this reunion of these two rocks prove that they have had the same origin? The Vulcanists, to make this agree with their theory, are obliged to have recourse to quite a forced supposition, according to which there have been alternately volcanic eruptions and submarine deposits; whereas this alternation of beds of different rocks, of nearly contemporary formation, has more than one example in mountains.

"10. There are many basaltic regions where

"* The same observation as in note upon article 5."

basalt is only found on summits, and it is evidently perceived by the correspondence of the beds, that all these summits were parts of one and the same bed, which spread over all the country: now, that is not the nature of volcanic deposits; they form currents, which take a certain direction, and no similar examples of such vast deposits are known, but among rocks produced by water, and particularly among stratiform rocks.

"11. Basalt has no appearance of fusion; heated in a furnace it melts to glass. It is true, that from Hall's experiments, a stony substance has been obtained; and that may very well happen, since nature produces it in burning volcanoes. But these cases are very rare, and Hall has justly observed, that in his experiments this appearance depended on the management of the cooling: but it must then be supposed, that this circumstance is always met with in the volcanic eruptions, which are supposed to have produced the mountains of trap.

"12. The prismatic division of basalt has been attributed to the water of the sea, which they say then covered all the region upon which these lavas have run: that is possible; but this accelerated refrigeration should, according to Hall's experiments, give the lavas a vitreous appearance; which is not the case even in portions of the mass.

"13. The conical form of basaltic mountains proves nothing; it is true, that such is the form of volcanic mountains, but in general it is that of all mountains whose sides are covered with earthy substances. Melted substances, ashes, give this form to volcanic mountains; and if basaltic mountains assume also more particularly this appearance, it is because their fragments are quickly reduced to this earthy state, so that they naturally form slopes on the sides of mountains.

"Moreover, the conical form of basaltic mountains is not that of burning volcanoes: the former are cones, isolated one from another, nearly equal in height; whereas volcanic mountains are grand coniform elevations, whose slopes and sides are loaded with little conical summits.

"One might extend much farther this chain of motives on which both theories are founded, but longer details would be here superfluous*;

"* It may be observed, that the points of division are often in matters of fact; as the existence of scoriæ, vitrifactions, that of craters, &c. I do not pretend to discuss their legitimacy.

"Perhaps both parties may think that I have not done justice to their arguments, and that I have overlooked some important ones. I believe not: I endeavoured to reconcile them, at least the principal; but I confess if any have escaped me, I should easily console time may perhaps some day afford the definitive solution of this great geological problem. Dolomieu occupied himself much upon it; and he doubtless would have succeeded in uniting both parties, if death had not overtaken him in the midst of his labours. He adopted neither of the two opinions: he was persuaded that both were admissible, according to localities; because having often seen in the products of the burning volcanoes of Italy, rock entirely resembling basalt, and even other primitive rocks, he had found by long experience, that only the characters of locality would decide on the origin of either. He had, according to this principle, observed some basaltic countries, among others Auvergne and the Vicentine, and he had regarded them as volcanic. I chiefly cite these two examples, because I know that many celebrated German mineralogists are of a contrary opinion*."

A yet later French mineralogist has thus expressed his sentiments upon this curious and long-agitated subject.

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myself, if I thought that would induce the advocates of the two opinions to publish fresh memoirs, to undertake their own defence. This great quarrel has been long hushed, and probably both parties have collected new observations."

* Brochant, ii. 612.

Brongniart's idea.

"We shall give a third opinion upon the origin of basalt, in a medium between the two preceding ones, and which appears to us the most probable. The naturalists who profess it, as Fortis, Dolomieu, Delrio, Spallanzani, think that the discussion on basalt is often a dispute of mere words:– that if this name is given to those stones whose characters we explained at the beginning of this article; some are truly volcanic, while others have entirely an aqueous origin; that the basalts of Saxony, and those of Ethiopia, certainly belong to this second division, and that it is probable that those of Scotland and Ireland also belong to it; while those of Italy, and Auvergne, should be arranged in the first class totally, or at least in part.

"Other naturalists, and particularly M. Patrin, imagine that basalts are the productions of the muddy eruptions of submarine volcanoes; and that the nature of the eruption, and the influence of the water, have given to this lava those particular characters for which it is remarkable. They believe that the latter influence prevented the basaltic matter from calcining or burning those substances on which it flowed. This hypothesis, which seems one of the most probable, if not applied without exception to all basalts, explains well enough the alternation of beds of prismatic basalt with beds of basalt, or stony and earthy matter without order; that of these same beds of basalt with sand-stone, with carbonate of lime, or with coal, which are not altered by it; in short, the presence of fossil shells in some basaltic beds. The causes which, in this hypothesis, concurred in the formation of prismatic basalt, no longer existing, we see why basalt is no longer formed in those vast currents of lava which in our days have issued from volcanoes. It seems that it is with basalt, as with veins, crystallised beds, fossils properly so called, &c. Nature in her present quiescent state no longer forms any*."

The extent of these observations will be pardoned, as there is not, in this science, a topic more difficult or interesting: but we must now return to a more immediate view of this celebrated substance.

STRUCTURE I. AMORPHOUS.

This rock, as already mentioned, is the trap of the Swedes, who first recommended it to modern notice; while the basaltic columns of Saxony had been observed by Agricola, the restorer of mineralogy in the sixteenth century. Whatever be their origins, these two substances are identically the same; as the same results may be produced either by the humid or the dry processes of chemistry.

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* Brongniart, i. 473. He had observed, p. 470, that lava entering the sea becomes fixed on the surface, and does not assume a columnar form, which rather proceeds from slow cooling.

Aspect 1. *Uniform.* The columnar basaltin had, as already mentioned, attracted great attention by the beauty and regularity of its forms, as early as the sixteenth century; but trap, or stratiformed basalt, may be called a discovery of the Swedes. The hill of Kinnekulla, in Westrogothia, was one of the first observed; and also that of Hunneberg, in the same province.

Black basaltin, from Kinnekulla and other parts of Sweden.

Grey basaltin, from the same.

Greenish, from Norberg.

Reddish, from Sweden.

Black basaltin, with small needles or scales of siderite, from Sweden.

Stratified basaltin, from Faroe, Staffa, the Giants' Causey, &c. where it sometimes underlies the columnar.

The same, from the castle hill of Edinburgh, Dunbarton, and other parts of the south of Scotland.

The same, from Andernach on the Rhine.

The same, from the Sierra Morena, or Black Mountains, in Spain.

The same, from Toplitz in Bohemia.

Black basaltin, from Egypt.

Green, from the same.

Red basaltin, from Channelkirk in Scotland.

Brown, from the same.

Stratiformed basaltin, from Saxony.

The same, from Etna, Vesuvius, the isle of Bourbon, New Spain, and other volcanic regions*.

Aspect 2. Mingled. Basaltin, with nodules of steatite, from the isle of Skey in Scotland, Westrogothia, &c.

Black basaltin, with red zeolite, from Sweden.

The same, with white zeolite, from Staffa, Giants' Causey, &c.

The same, with many beautiful varieties of zeolite, from the Faroe isles.

The same, with zeolite, from Etna, &c.

The same, with grains of pyrites, from Hunneberg in Sweden, Dauphiny, &c.

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* Saussure mentions, § 1497, a kind of basalt which may be called laminar: and, § 548, a singular *roche de corne,* (basaltin ?) in thin leaves, with mica, quartz, and felspar. If compact, he says, it would have formed a genuine porphyry. How ?

The same, with nodules of calcareous spar, from various parts.

The same, with red jasper, from Derbyshire.

Basaltin, passing in veins through granite, from Norway. With inherent pitchstone, from the Rhine.

Aspect 3. Basaltic Tufa. This substance has been observed at Staffa, and in some other basaltic countries. A considerable portion of Arthur's seat, near Edinburgh, is composed of it.

Aspect 4. Basaltic Bricia. Bricia, with fragments of granite, on a base of basaltin, either black, grey, or green, from Westrogothia in Sweden, or from Dauphiny in France.

The same base, with fragments of quartz, from the same.

The same, with fragments of limestone, from the Alps of Dauphiny.

The same, with fragments of slate, from the same, and from the mountain of Tarare, near Lyons.

The same, with fragments of granite, slate, and limestone, all mingled, from Tarare, and Dauphiny.

The same, with fragments of porphyry, from the hill of Lesterelle in Provence.

Bricia of fragments of basaltin, joined by a cement of quartz, intermixed with particles of basaltin. Uncertain.

STRUCTURE II. COLUMNAR.

Basaltin of Stolpen.

Aspect 1. Uniform. Basaltin, from Stolpen, in Saxony: Remarkable as having attracted the attention of Agricola, and other naturalists since the sixteenth century. The little town of Stolpen is built upon the side of a basaltic hill, a few miles to the east of Dresden. The lower part of the hill consists of a granite, of white felspar, grey quartz, and black mica, upon which the basalt reposes, presenting the most beautiful and regular columns observable in Germany*. They have commonly six sides; but some have four, five, seven, or eight; yet their length does not seem to exceed fifteen or sixteen feet. The columns are vertical; but on the south-east there is a rock of stratified basalt, of that kind which appears in thin plates or tables. The basaltin of Stolpen is black with a bluish cast, the grain being impalpable, the fracture conchoidal, and the fragments sharp. Its hardness, like that of siderite and basalt, equals that of iron the hardest metal, being more than 800 of Quist's gradation. This basaltin often presents little cavities, lined with chalcedony, and quartz crystals; sometimes filled with green steatite, calcareous spar, zeolite, or a lithomarga, resembling semiopal. Small grains of olivine also occur, and dots of siderite, or perhaps augite. The pillars are used for many useful and ornamental purposes of architecture; an example which might be followed in other basaltic countries, with a sacred regard however to the more regular, grand, and conspicuous parts.

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* Daub. sur les basaltes, 42.

Columnar basaltin, from Italy, Sicily, Auvergne, Hungary, Bohemia, Saxony, Lusatia, Thuringia, Hessia, Goetingen, Nassau, in Germany; from the isle of Bourbon, New Zealand, and other isles in the South Sea, &c. &c. The columns are often so small as to be chosen as specimens.

Aspect 2. Mingled. Columnar basaltin, mingled with zeolite, from many countries.

With nodules of steatite, calcareous spar, chalcedony, lithomarga, olivine, &c. from Stolpen, and other places.

MODE IV. BASALTON.

Characters. Texture coarse, and of a large grain, mixed with quartz or felspar, but lax, and incapable of the fine polish of basalt or basaltin.

Hardness marmoric. Fracture commonly even. Fragments blunt and amorphous.

Weight sometimes siderose, generally granitose.

Lustre glimmering. Opake.

Colour grey or greenish.

Name. As the Italian termination *ino* designates diminutives and substances of a finer nature, so that in *one* is employed to discriminate those of a coarse appearance or large grain. Hence the name *basalton* is adopted for another branch of the basaltic family, that called *grunsteins* by the Germans, an appellation alike vague and barbarous, as are most of those terms derived from the vulgar miners. The most important and beautiful of the grunsteins, a mixture of crystallised siderite with felspar, has been already described after siderite. By basalton are understood the other kinds of grunstein, except the porphyries; being a mixture of coarse basalt, without the splendour or cohesion of that substance, with either felspar or quartz. Even that

Coarse grunstein.

with a finer grain must still be regarded as a coarse rock, as it does not admit the polish of basalt or basaltin. The common whin-stones of the north of England and of Scotland belong to this class. It is unnecessary to indicate many examples of so common a substance, which is chiefly interesting from its intimate connexion with basalt and basaltin, often passing either into the one or the other of these substances.

Werner has considered grunstein as either primitive or stratiform. The former has been here described under the venerable name of Wallerite; the latter, which commonly covers the beds of basalt, is that about to be mentioned. It would appear that he has since added a transitive grunstein, distinguished by veins or grains of quartz, in Voigtland called *leberfells*, or liver rock, being coloured with a reddish brown oxyd of iron. This transitive grunstein occurs in the Hartz, in Bohemia; and, according to Mr. Jameson, in the upper part of Dumfries-shire. The Wernerians regard grunstein as a more chemical solution than basalt, though it commonly rest upon the latter; while in general the more chemical dissolutions are the lowest: a circumstance which they endeavour to explain by supposing the superincumbent waters more agitated at one period than at another.

STRUCTURE I. COMPACT BASALTON.

Compact basalton, from some of the interior pillars of Stonehenge.

Basalton, or whin, from Salisbury Crags, near Edinburgh.

The same, from the Malvern hills.

Basalton is common in the pavement of London.

STRUCTURE II. SLATY BASALTON.

Grunstein slate.

This is the green-stone slate of the Germans, being composed of siderite and compact felspar, or felsite, which is sometimes more abundant than the former. It is said to form mountains in Sweden, and abounds near the mines of Adelfors, being often metalliferous. If the felsite generally exceed in quantity, it ought to be classed under that rock.

Klinkstein.

The porphyry slate, or clink-stone porphyry, of Werner, *basalte en table* of the French, seems an intimate mixture of iron and felsite, and is often found in basaltic countries. It has been analysed by Klaproth, who found eight parts of soda in a hundred. How it came to be classed among the basaltic family can scarcely be imagined, except from its local situation, a circumstance too preponderant with Werner; it being as often found in the vicinity of basaltin, as lava with a base of felsite is in that of lava with a base of siderite. It is surprising that the French mineralogists have not adduced this circumstance in favour of the volcanic origin of basaltin. Clink-stone however has no sort of relation to the family of basalts, as the chemical analysis infallibly demonstrates; for it only contains 3 in the 100 of iron, while all the other modes present more than 20. It is therefore here classed under Felsite, with which the analysis strictly corresponds, except that there is double the quantity of iron, which imparts the black colour.

MODE V. PORPHYRY.

Name.

This rock belongs to the division here called *Intrites*, as consisting of crystals or grains imbedded in a base or paste, in contradistinction to Granites formed by simple coherence, and to Glutenites, (both also derived from the Latin), in which the particles are cemented together by the same or by a different substance, scarcely visible, or at least not so abundant as in the Intrites*. This last denomination, besides instantly recalling to memory the nature of the rock, would prevent the misapplication of the classical term porphyry to many substances, which have only a very faint and distant resemblance.

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* In like manner the Glandulites of Saussure are those stones which include glands or kernels.

The term porphyry is therefore here restricted to its proper and peculiar sense of a base sprinkled with crystals of felspar. The word in the Greek implies a purple, or rather red stone; and in severe classical precision ought to be confined to that colour, common among the monuments of antiquity: but as denominations derived from colour, the worst of all distinctions, have been forced to be extended, the black, the grey, the bluish, and even the green, having the same base of trap or basaltin, must be included. But the base being the sole ground of the present classification, all the other kinds are considered as Intrites, and reserved for separate descriptions.

Base. It was long imagined that the base or ground of porphyry consisted of jasper; but this supposition has been finally rejected, and it has been found to be trap, from its fusibility and other chemical properties, and likewise from its external attributes. Like basaltin, it presents crystals of siderite, grains of quartz, and sometimes glandules of chalcedony and of steatite, which last perhaps forms the green matter in Swedish porphyry. The crystals of felspar are generally rectangular, but sometimes oval or otherwise irregular. When they are scarcely visible to the naked eye, the substance is here called porphyrin; and when they exceed an inch in size the term porphyron may be applied.

Werner's Porphyries.

Genuine porphyry abounds in many parts of the world, and often forms entire mountains. Like siderite it has been found to alternate with gneiss, and it occurs in a columnar form. Among the defects of orology, and even of the Wernerian theory of formations, may be chiefly particularised the classification of the porphyries, vaguely so called, which are arranged under one head, whether the base be keralite, felsite, pitchstone, or even serpentine, or indurated clay; while felspar, like mica, may be occasionally found in most rocks, and these pretended porphyries ought all to be referred to their several bases. The name has even been extended to rocks with calcareous or other crystals: and as strict definitions form the first foundation of every science, no argument can more clearly evince the necessity of new and abundant denominations of rocks, than this confusion of substances of a nature wholly remote; and so frequent and important, that no geological work can be properly understood, except the author use much circumlocution. For to extend the term porphyry to every substance in which small crystals are imbedded, is as absurd as it would be to confound granular limestone with granular quartz; or any other remote substances merely of similar structure, or even aspect.

STRUCTURE I. PORPHYRY WITH LARGE CRYSTALS OF FELSPAR.

Aspect 1. Red Porphyry. This kind is frequent in ancient monuments. The crystals are seldom so regular as those of the next structure. It is sometimes interspersed with globules of a finer porphyry, or even of porphyrin.

Porphyry, from Egypt, or the ruins of Rome.

The same, from the Grampian Mountains in Scotland. It chiefly occurs in Glenco*.

The same, from Corsica.

Aspect 2. Black. A fine column of this kind is in the church of St. Prassede, at Rome.

Aspect 3. Green. This has sometimes been called verd-antique, but the proper verd-antique is a mixture of serpentine and white marble. The green porphyry has also been erroneously supposed to be one of the Ophites, or snake-stones of Pliny.

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* Which must not be confounded with Glen Cro, not far from Inverary.

Ophite.

Saussure, and innumerable others, misled me concerning the Ophites of Pliny. The passages are:

Pretiosissimi quædam [marmora] *generis, sicut Lacedæmonium viride, cunctisque hilarius. Sic et Augusteum, ac deinde Tiberianum, in Ægypto, Augusti ac Tiberii primum principatu reperta. Differentiaque eorum est ab Ophite, cum sit illud serpentium maculis simile, unde et nomen accepit; quod hæ maculas diverso modo colligunt; Augusteum undatim crispum in vertices; Tiberianum sparsa, non convoluta, canitie. Neque ex Ophite columnæ nisi parvæ admodum inveniuntur. Duo ejus genera, molle candidum, nigricans durum.* xxxvi. 7. edit. Brotier, Paris 1779, 12mo.

Again, c. 22, speaking of stones used for making mortars. *Potiorem ex alabastrite Ægyptio, vel ex Ophite albo. Est enim hoc genus Ophitis, ex quo vasa etiam et cados faciunt.*

These passages may be thus interpreted:

"Some marbles are of a very precious kind, as the green of Lacedemon, which is also more cheerful than any of the others. So also the Augustean, and afterwards the Tiberian, first discovered in Egypt during the reigns of Augustus and Tiberius. The difference between these marbles and ophite consists in this, that the latter resembles the spots of serpents, whence its name is derived; whereas the marbles display their spots in a different manner, the Augustean being crisped into wavy tops, while in the Tiberian the white is scattered, not convolved. Nor can any columns be formed of ophite, except of a very small size. There are two kinds of it, the white being soft, the blackish or grey hard." He then proceeds to state that both were used to appease head-achs, and against the wounds of serpents; particularly a kind of ophite named Tephria, because it was of the colour of ashes; and also called Memphites, from the place where it was found, being of a gemmose or sparkling appearance.

The other passage implies that "good mortars may be made of Egyptian alabastrite, or of white ophite, for this is a kind of ophite of which they make even vases and larger vessels."

Lucan also has,

> Quam parvis tinctus maculis Thebanus ophites.
>
> "Like Theban ophites tinged with small spots."

Pliny is not very accurate, and it is more probable that the ophite came from Thebes in Upper Egypt, than from Memphis. It must however have been wholly remote from green porphyry, being probably the Thebaic stone, mentioned by Theophrastus, of a dark colour sprinkled with golden drops; that is, as Wad explains, a dark ollite interspersed with golden mica*. The white was probably a spotted marble or alabaster, for the ancients arranged stones by faint resemblances; but white ollite, or rather massive steatite, is not unknown in Saxony and other countries.

Green porphyry occurs in large blocks near Ostia, which, as Ferber observes, was the old harbour where the Egyptian ships unloaded†: but all the other ships bound for Rome also arrived there; nor do I find any mention of green porphyry in the memoir concerning Egyptian geology, which M. Roziere presented to me. This porphyry contains crystals of siderite, and frequently spots of chalcedony. Ferber observed the following varieties:

Ferber's observations.

Dark green, with fair green spots; common.
Dark green, with white spots.
Dark green, with black spots.

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* Fossil. Ægypt. p. 27. This subject will be further illustrated in treating of the Magnesian Rocks, and of the ancient marbles, where it will be seen that the green porphyry was unknown till the latter times of the Roman empire. In describing this substance, Da Costa, p. 288, justly observes, that there are no Grecian nor Roman relics of it; and he concludes that very little was found even in Egypt. It is now well known that it is not an Egyptian product; but vast masses remain near the port of Ostia, where it was probably left on the irruptions of the barbarians in the fifth century, when the arts were interrupted and abandoned.

† Travels in Italy, 225.

Fair green, or yellowish green, with black spots.

He also mentions a dark green porphyry, of which the trap base sometimes passes into crystals of siderite; while the large white crystals of felspar are so numerous, that it might be called a white porphyry.

It is believed that green porphyry of this structure is found in Ireland, and in Cumberland, and also in Norway.

The ancient was probably found in Thessaly, as will appear in discussing, under one point of view, the Ancient Marbles in Domain V.

Saussure's statement.

Saussure mentions the following:

A porphyry with a base of greenish grey felsite, with very small crystals of felspar, and some globules of lime; the presence of the latter in so hard a rock being regarded as singular. § 1578.

A singular porphyry of a chocolate colour, with crystals of blue felspar. § 1448.

Not far from Frejus is a mountain of red porphyry, with some grains of quartz. § 1453.

At Esterelle, between Nice and Frejus, are rocks of porphyry, the base being of the colour of wine lees. § 1436.

Porphyries of Durance.

He also gives the following account of the porphyries which he observed in pebbles, in the bed of the river Durance, which has been long celebrated for its variolites.

1539. B. "*Green porphyry.* The cement of this porphyry approaches likewise to that of the ophite[*]; its colour is however less beautiful: it is a green which verges to the deep grey: it likewise assumes a surface less uniform and less soft to the touch. In other respects its fracture and hardness are the same, but it is a little more refractory, and the glass it yields is less hard and opake. The small fragments of this glass are however attracted by the magnet.

"The crystals of felspar which this porphyry contains are, as in the ophite, lengthened oblique angled prisms, of a white inclining a little to green; of an unctuous and milky lustre; their fracture is more compact, and presents thicker laminæ than common felspar.

1539. C. "*Red porphyry.* The cement of this porphyry is of what I call *primitive petrosilex.* In the rolled pebbles its surface is pretty uniform, almost soft to the touch. It breaks into irregular fragments in sharpish angles, almost opake on their edges. Its fracture is scaly with very thin scales, which, viewed by a microscope, appear semi-transparent and whitish, whilst the base is of a pretty deep wine red.

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[*] By ophite, Saussure, like many others, erroneously understands the green porphyry.

"This cement is more than semi-hard, it easily gives sparks under steel, and may nevertheless be scratched by a knife, the streak being of a rose colour. It melts with difficulty under the blow-pipe into a semi-transparent glass, grey and full of bubbles, mixed with some brown dots, which are attractable by the magnet.

"The grains are of felspar, white, yellowish, rarely crystallised with regularity, and of the unctuous nature of the preceding.

1539. D. "*Black porphyry*. The paste of this is of a fine deep black, approaching a little to blue: its exterior surface is pretty uniform, and almost soft to the touch. Its fracture delicately scaly, as that of the preceding; but its hardness rather less, although it yields some sparks. It is still more refractory; the flame of the blow-pipe only whitens and blunts it a little on the thinnest edges.

"The grains, of a greenish white, have no regularity; they are cemented in the black base of the stone, in all sorts of forms. Their fracture is most frequently scaly: there are however to be seen some marks of the laminar texture of the felspar, and it is also, as in the others, of the unctuous kind.

1539. E. "*Brown porphyry*. Its cement is brown, rough, and of an earthy aspect; it is however pretty hard. The grains, seldom regular, are of an unctuous felspar, a little compact, and of a greenish tint*.

1539. F. "*Grey porphyry* with a cement of petrosilex, of a greenish grey, enclosing a number of crystals of unctuous felspar of the same colour, though a little whiter, some pyrites, and some black ferruginous spots.

1539. G. "*Schistose porphyry* with a blackish cement the colour of iron, with a scaly and brilliant fracture, hard, containing crystals of dry white felspar, opake, which bubbles and readily melts under the blow-pipe, and other crystals of hornblende, pretty hard, of a blackish green."

Add porphyry with black chalcedony, from Chemnitz, in Saxony. (Linn. à Gmelin, 206.)

Aspect 4. Blue. Dark indigo blue porphyry, with crystals of yellowish felspar, from the isle of Rasay, Scotland.

See Mr. Jameson's Mineralogy of the Scotish Isles, ii. 117. He says the base is betwixt clay and hornstone, so it is only placed here to excite further enquiry concerning so beautiful and uncommon a rock.

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* Verd d'oeillet. The French of Swiss and German authors is often peculiar.

STRUCTURE II. WITH SMALLER CRYSTALS.

Aspect 1. Red. Of Egypt, the felspar being frequently in white or in flesh-coloured prisms[*].

The same, with white only, the porphyry of Pliny. It is sometimes interspersed with masses of a lighter or darker colour.

The same, from Corsica, from Lesterelle in Provence, Scotland, &c.

The same, with crystals of siderite.

Aspect 2. Brown. Of this Ferber mentions two varieties; the liver brown with light green spots, and the dark brown with spots half black and half green; perhaps he means crystals of black siderite and green felspar.

Dark brown porphyry, speckled with numerous small crystals of felspar, and others of siderite and quartz, with reddish and green nodules, from Sweden, where it is manufactured and takes a high polish.

Aspect 3. Black. Entirely resembling the red, except in colour. Of this there are two large columns in a church near the gate of St. Paul, at Rome.

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[*] Wad, 12.

Aspect 4. Green. Resembling the red.

The same, with crystals of siderite.

From Ferber's description it would seem that the felspar is wanting, in which case it is a trap or basaltin.

The same, with small crystals of felspar in white spots, commonly irregular, and twisted like worms; the *Porfido verde fiorito**.

The red also occurs in Egyptian monuments, as well as the black †. Green porphyry is also found in Corsica and Norway.

MODE VI. PORPHYRIN.

This name has been adopted for porphyritic substances, in which the crystals of felspar are so small as almost to escape the eye, or not be discoverable without a lens. But somewhat of the regularity of true porphyry must be observable, otherwise the substance must be considered merely as a mingled basaltin. On the other hand, the mixture of a few grains of quartz may be admitted in a porphyrin; but if the base assume the granitic form, it must be regarded as a granitic porphyry.

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* One kind so called is not a porphyry, but a waved mixture of siderite and felspar, as if daubed with a brush. See Anomalous Rocks.

† Wad, 12, 13.

Swedish porphyry.

The Swedish porphyry, already mentioned, approaches nearer to a porphyrin; specimens of which are common in most porphyritic regions, forming the passage from basaltin to porphyry.

MODE VII. PORPHYRON.

When the crystals of felspar exceed an inch in length, and are distant from each other, circumstances which occur in the large scale of nature, the rock may be termed Porphyron. The utility of these divisions will be more fully understood, as the science becomes more and more studied.

MODE VIII. PORPHYROID.

This denomination includes such substances as approach the porphyritic structure. In a strict derivation of the term porphyry, as already explained, the black and green kinds could only be termed porphyroids; but as this severity would too much violate common usage, the term porphyroid, as admitted into the siderous division, must be restricted to such rocks as have a base of siderite, basalt, or basaltin, presenting an appearance of porphyry. Some of the primitive grunsteins of Werner fall under this distribution. When the base is siderous, but the square crystals are barytic or calcareous, &c. this denomination may also be adopted*. The mixtures called granitic porphyroids, &c. are to be arranged under their proper domains.

MODE IX. AMYGDALITE.

Where the distinctive characters of a substance vary much, they are omitted, to avoid unnecessary prolixity, especially as they may be found in the common books of mineralogy; and rocks should be studied in themselves, as well as in books, for the only use of any classification is to assist the memory.

This substance, the *mandelstein*, or almond-stone of the Germans, has a base of coarse trap or basalton, in general black or brown, interspersed with nodules or kernels of chalcedony, agate, calcareous spar, zeolite, and green mag- Agates.

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* The green siderite, with crystals of calcareous spar, (Sauss. l. 139, 4to.) may belong to this division.

nesite, or magnesian earth mingled with iron[*]. The agates afford valuable materials for manufacturers; and the rock abounds in many countries, as at Oberstein on the Rhine, Kinnoul and other places on the river Tay, in Scotland, whence the English lapidaries have called the latter agates Scotch pebbles[†]. In the north of Italy the same rock presents chalcedonies, which are sometimes enhydrous, or contain a drop of water. In the Faroe isles the chalcedony commonly assumes the stalactitic form; and, as Landt observes[‡], it has been found modelling itself on straw or moss, whence it clearly appears to have been deposited by water; either heated by its own caloric (for if water contained no principle of heat it would become ice), or by subterraneous fires, as the fountain of Geyser in Iceland deposits silicious concretions.

Formations.

Werner considers Amygdalite as of two formations; the Transitive, the base of which he calls wacken, an argillaceous rock, sometimes inclining to basaltin, which it generally accompanies, and sometimes to iron-stone, a mixture of iron and clay, which is also the chief repository of prehnite. The other formation belongs to his Floetz, horizontal, or stratiform rocks; and he also describes the base of this as being wacken, or rather decomposed grunstein, which, according to his theory, generally lies under basaltin and above clay. But Mr. Jameson, to whom we are greatly indebted for an exposition of the Wernerian system, omits amygdalite in his description of wacken; and Brochant regards the base of amygdalite as a decomposed siderite or grunstein, and it certainly belongs to this domain. It is believed that olivine, though frequent in basaltin, has never been observed in amygdalite, in which the silicious parts assume a different form.

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[*] This may also be called a *bole,* a shorter word than *lithomarga,* and expressive of the same substance, as appears from the analyses.

[†] This name seems also a distinction from the English pebbles in pudding-stone, &c. some of which are as beautiful as agates.

[‡] P. 146.

Origin.

Some French mineralogists have supposed amygdalite to be of volcanic origin; but Patrin, though an ardent volcanist, has rejected this idea, and arranges it after porphyry, as he observes that the base is sometimes siderite, sometimes trap. The cavities are also larger than any found in lava; and though agates be so named from the river Achates in Sicily (in the south of that country, and at a great distance from Etna), it appears not that agates have ever been observed in any volcanic region.

Amygdalite, like basalt, often contains nodules of common steatite, and small crystals of siderite. As it only takes a very coarse polish, the base is properly a basalton.

STRUCTURE I. AMYGDALITE WITH AGATES.

From Oberstein on the Rhine.

The same, with cubic zeolite.

The same, with veins of glassy chalcedony, accompanied with a band of the colouring matter, which would form agate.

Brown amygdalite, from the same.

Amygdalite, with chalcedony, zeolite, &c. from the Isle of Skey.

Kinnoul.

Faujas has given a good list of the products of Kinnoul, but ridiculously calls them lavas. He mentions black basaltin joined to basalton, the latter presenting small crystals of felspar, so as to assume a porphyritic appearance. The same compact basaltin, in columns. Green basalt, very firm and sonorous. Basalt with crystals of felspar, and attracting the magnet. A square prism of the same, with a carnelian on one of the sides. The same, with globules of green earth, agate, and calcareous spar, &c.

Moca.

Beautiful agates, or what are called mocastones, also occur in a rivulet called May, which falls into the Ern near the house of Condie, in

Perthshire. Moca-stones are also said to be found on the banks of the Tweed, being chalcedony mingled with green earth, bitumen, &c. in the form of moss, and other appearances. They receive their name from Moca, in Arabia; that is, like many other substances, not from their native site, but from the mart where they were sold, being brought to Moca from Cambaya in Hindostan, which also transmits beautiful carnelians and chalcedonies*. There are probably rocks of amygdalite in that vicinity. It would appear however that this rock is among the rarest products of nature, having seemingly been observed only in the four countries above mentioned; Hindostan, Sicily, Scotland, and the neighbourhood of Oberstein.

STRUCTURE II. AMYGDALITE WITH CALCAREOUS SPAR.

Toad-stone.

Of this the toad-stone of Derbyshire affords a well-known example. Patrin mentions another from Strelka, in Siberia, with crystals of felspar and globules of steatite, in a base of liver-coloured trap. Variolite of Drac. The variolite of the Drac, a torrent which throws itself into the Isere beneath Grenoble, also belongs to this division. The base, according to Patrin, is of trap, mingled with clay, or what the German mineralogists would call a wacken, being of a grey or violet colour, with spangles of felspar and globules of calcareous spar; sometimes also with globules of green steatite. In like manner the toad-stone of Derbyshire is occasionally, though rarely, of a light brown colour, with green spots. Saussure regards the variolites as primitive rocks; but Werner only classes them as either transitive or stratiform.

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* It is said that the fine carnelian is produced by art from nodules of a kind of chalcedonic flint, which are left in the heat of horse-dung for many months. One of these flints I received from my highly-respected friend Mr. Ferguson, whose noble collection of minerals is known to all Europe. But, in the oriental phrase, his love of science, and generous spirit, surpass all the gems in his cabinet.

Black amygdalite, or toad-stone, from Derbyshire.

The same, with veins or nodules of red jasper.

Dark brown toad-stone, from the same.

Light brown, or fawn-coloured toad-stone, with green globules, from the same.

Variolite of the Drac, the Hartz, &c.

The calcareous spar sometimes decomposes, and leaves a false appearance of lava.

STRUCTURE III. AMYGDALITE WITH OPEN PORES.

This substance abounds in the high upland of Mexico, where it is of a reddish colour, and is the *tetzontli* used in building. As that region abounds with volcanoes, it is probably a lava.

MODE X. IRON-STONE.

Characters.

Texture, compact, granular or earthy, sometimes undulated. On the surface of English hills composed of this substance, it often presents a singular ornamented appearance, as if derived from pinnæ, or some other long pyramidal shell, with transverse bars; and is sometimes covered with yellow rust from the decomposition of the iron.

Hardness, basaltic. Fragments, amorphous, rather sharp.

Weight, siderose.

Lustre, dull, opake.

Sites.

This substance forms many small chains of hills in England, as in Surry, &c. and in other countries, yet has scarcely been identified in books of mineralogy. Ferber, in his oryctography of Derbyshire, mentions iron-stone as composed of a bluish heavy clay, with an appearance of containing much iron; he also mentions a brown kind, found in the coal-mines of Stansby. This rock contains from 20 to 40 of iron, and when rich in that metal is worked as an ore; being a *Gemeiner Thoneisenstein* of Werner, which contains about 40 parts of iron in the 100. But none are here intended to be included which exceed 20 or 25. It is supposed generally to indicate coal; and if so, that mineral may be expected in Surry. The clay-stone, or argillaceous iron-ore, has commonly a brown or red appearance; while this is grey or black, and probably contains no more iron than basalt. The name iron-stone is commonly used in Surry and other counties; but it probably is one of the vague *whins* of the North. It is on the gangart of prehnite*.

STRUCTURE I. COMPACT.

Iron-stone, from Surry, Shropshire, &c.

The same, with prehnite, from Dumbarton, &c.

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* Mountains of iron-stone exist in the East, if we credit Arab. Nights, vi, 239, of Dr. Scott's edit. 1811.

STRUCTURE II. COLUMNAR.

Mr. Sowerby possesses in his valuable museum a curious example of this kind, being quadrangular columns of iron-stone passing through slate.

STRUCTURE III. VARIEGATED.

This kind, with an appearance of shells, &c. has been already mentioned.

Rock of the Capitol.

The rock upon which the Capitol of Rome was founded, is thus described by Breislak. 1. The colour is brick red, but with spots of a deeper tinge, and which are also of a larger grain. 2. Its hardness surpasses that of tufa, but is inferior to that of lava, being comparable with that of the freestone used at Paris. 3. If large pieces be broken off with the hammer, the fracture is even conchoidal; in small the fracture is unequal, small grained, but never rough. 4. It acts on the magnetic needle at the distance of two or three lines. 5. It contains scales of mica, fragments of felspar, and white globules of calcareous spar, with some fragments of melanite. 6. Observed in the sun with a good lens, the whole mass is found to be crystallised.

If this rock be not a red basalt, it may pass into the Mode of Iron-stone, as appears from its action on the magnet.

The stone which serves as a gangart to the quartz crystals called Bristol diamond, may also be ranked in this division; but it seems to be only a vein-stone passing through limestone. Various kinds of iron-stone, siliceous and argillaceous, often occur in mines, but have not been found to constitute rocks.

The following substance may also be added to this division.

Iron clay of Werner.

" Iron clay.

" Eisenthorn.—Werner.

" *External Characters.*

" Its colour is commonly brownish red, which seldom approaches to blood red, but more often to reddish brown.

" Occurs almost always vesicular, sometimes with empty, sometimes with filled vesicles.

" Internally it is dull.

" Fracture fine, earthy, sometimes inclining to conchoidal.

" Fragments indeterminately angular.

" Is soft, but sometimes passes into semi-hard.

" Is not particularly difficultly frangible.

" Not particularly heavy, in a middling degree.

"*Geognostic Situation.*

"It belongs to the floetz-trap rocks, and constitutes, like wacken, the basis of amygdaloid.

"*Observations.*

"It is distinguished from wacken by its colour, and the greater proportion of iron which enters into its composition.

"2. The iron which it contains is very much oxydised, whereas that in basalt is slightly oxydised."*

MODE XI. JASPER.

Characters.

Texture, very fine grained and compact, sometimes rather earthy.

Hardness, crystallic, sometimes only felsparic. Fracture, conchoidal. Fragments, angular sharp.

Weight, sometimes siderose, sometimes granitose.

Lustre, glistening, rising to shining, but sometimes dull. Opake; sometimes translucent on the edges, but it then passes to jaspagate.

The most frequent colour of jasper is the red, which has been found to contain from 16 to 20 of iron, and often attracts the magnet. It is surprising that analyses have not been made of a substance regarded as valuable.

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* From the additions to Mr. Jameson's Mineralogy, ii. 603.

Basanite. Basanite, or the Lydian stone, is by many regarded as a black jasper, seemingly with reason, for its geognostic relations in veins, &c. resemble those of the other jaspers, and small veins of quartz often traverse both kinds.

White jasper. The existence of white jasper has recently been granted; but even this colour does not refuse the presence of abundant iron, as may be observed in the white ore of iron called steel ore, or the spary iron ore, which is found to contain from 30 to 40 of iron, with more than 20 of manganese.

The black being admitted, jasper may be said to present all colours, except blue, which seems however to occur in New Spain, or at least a green approaching nearly to blue. Sinople. The sinople, or red jasper of Hungary, sometimes contains gold*; and is said by Born to hold 18 of iron. When Mr. Kirwan argues against this, from the comparative lightness, he forgets that many ochres, and even ores of iron, are comparatively light; nor is that metal itself of great specific gravity, being much inferior even to tin or copper.

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* The sinople of Heralds is green! The earth of Sinope (see Pliny) was red.

"Mountains of striped jasper occur in Siberia, and often with breccias, but without petrifactions, per Herman. 1 Berg. Jour. 1791, p. 84 and 94; of red jasper, ibid. 88; and also of green jasper, 2 Gmelin. 81. (French.) It often forms thick strata in mountains of schistose mica in the Apennines, Ferber, Italy, 109; and in Siberia, 2 Herm. 281. In Saxony it is found alternating with, and sometimes mixed with, compact red iron-stone, 2 Berg. Jour. 1788. 485. Sites.

"In the south of France it occurs, reposing on granite, and underlaying basalt, 3 Soulavie. 72. In the Altaischan Mountains it has never been found in contact with granite, but it sometimes underlays argillite. 6 Nev. Nord. Beytr. 115."*

At Salisbury Crags, near Edinburgh, a curious jasper, spotted with metallic iron, occurs under the basalt. Saussure and Dolomieu have observed that jasper is chiefly of an argillaceous nature, more or less penetrated with oxyd of iron. Patrin has given an interesting account of the mountains of jasper in Siberia †, where he Of Siberia.

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* Kirwan, G. E. 177.

† ii. 266.

conceives that what he calls petrosilex passes into jasper, by the influence of the atmosphere; but in this he judges from the colours, and not from the analysis. His primitive petrosilex, as he declares, is felsite, while he places jasper, which he calls primitive, after his secondary petrosilex, which he expressly mentions is the hornstein of Werner. There is therefore great confusion in his context, as he derives a primary rock from a secondary substance; and his petrosilex must be itself regarded as a dull and imperfect jasper; nor is it inconceivable that the surface may even attract more iron from the atmosphere, where atoms of that substance constantly float, as has appeared from many experiments and inferences. The most beautiful jaspers of Siberia appear on the eastern side of the southern part of the Uralian chain, particularly the ribbon jasper, green and red, and that spotted with pitchstone, or perhaps brown jasper. Another beautiful kind presents, on a bright red base, little undulating veins of olive green, accompanied by a white thread which follows all the undulations. In Daouria, on the left bank of the river Argun, one of the sources of the Amur, there is a famous mountain composed of green jasper; but, like the other kinds, it will not rise in large pieces, but splits into small fragments. He observes that jasper is generally schistose. A late traveller has informed us that mountains of jasper extend for perhaps more than a thousand miles through the eastern part of Siberia, including Gore Island, between that country and North America. On the contrary the grand chains of European mountains seldom or never present this substance; which is chiefly found in Sicily, Bohemia, and Saxony.

It must be observed that many of the jaspers rather belong to lithology or gemmology, being only found in geods or small veins. Nor is it intended to be affirmed that they all belong to the siderous domain, though the black, the red, and the green, which are found in the greatest abundance, appear always to belong to that division; and it may be observed that these colours also occur in basaltin, like which also jasper occurs in columns at Dunbar, in Scotland.

STRUCTURE I. COMMON.

Aspect 1. Black jasper. It is doubtful whether this substance, the basanite or Lydian stone of Werner, form entire mountains, though Kirwan seems rather to imply that it does: but the siliceous schistus of Werner, which includes basanite, is so vague an appellation as to convey no idea;

and the application of the term has embarrassed even the most skilful mineralogists.

Black jasper, from Prague.

The same, from Leipsic.

The same, from Hainchen, near Freyberg, in Saxony.

The same, from the Pentland hills, near Edinburgh*.

Aspect 2. *Red jasper*, from Saxony.

The same, with granite adhering to both sides, from the Spizleite, near Schneeberg.

Red jasper, or sinople, with grains of gold, from Hungary.

The same, from Siberia, where it rises in mountains†.

Aspect 3. *Green jasper*, from Daouria, where it composes a mountain.

Aspect 4. *Striped jasper.* In green and red stripes, from Siberia, where it forms a chain of mountains.

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* Brongniart, I. 327, regards the siliceous schistus of Werner as a *schistose jasper*. He might rather, with Faujas, have called it black jasper, most jaspers being schistose. As iron forms the dominant principle of jasper, and black is the most usual colour of its compounds, it would be absurd to reject black jasper.

† German and Dutch travellers sometimes call red jasper *coral*.

Brown jasper, it is believed, may also form mountains or rocks; but the other kinds, as the Egyptian, the jaspagate, &c. are only found in small pieces, commonly globular.

STRUCTURE II. COLUMNAR.

This structure is very rare, and scarcely occurs except at Dunbar, in the south of Scotland, where the interstices of the pillars are filled with siliceous cement.

MODE XII. SLATE.

Characters.

Texture, eminently schistose or slaty, commonly straight, sometimes curved or undulating, of a very fine or impalpable grain.

Hardness, from marmoric to basaltic. Fragments, sharp, splintery, sometimes rhomboidal.

Weight, granitose.

Lustre, sometimes dull, sometimes silky. Opake.

The colour is most generally bluish, but sometimes greenish, or a purple red; also yellowish, and sometimes with stripes or spots of a darker colour. It is the *thonschiefer*, or clay-slate, of Werner, the argillaceous schistus of many English

Names.

and French mineralogists, being by all ranked as a primitive rock. As it has been found to contain from 14 to 20 of iron, it strictly belongs to this domain, the clay being a very inferior consideration. It has also a metallic appearance and sound, very different from schistose clay or clay-slate, strictly to be so denominated. The simple term SLATE, besides the advantage of being in general use, has been thought sufficient to discriminate it by way of eminence. It generally contains a portion of magnesia; and when this is abundant, as appears to be indicated in those kinds which have a very silky or satiny appearance, it may be ranked among the magnesian rocks. It often presents pyrites, either in a cubic or dendritic form, sometimes schorl, and even garnet and siderite. Actinote also appears; and a recent discovery chiastolite, or hollow spar. Scales of mica often occur, as in many other substances; nay it sometimes passes into mica-slate: and Daubuisson has demonstrated, by an operose chemical analysis, that they may be regarded as different modes of the same ingredients.

It often forms entire mountains, but commonly only a part, alternating with gneiss and mica-slate: nay, according to Kirwan and Pallas, both granite and gneiss often rest upon slate.

Sometimes veins of granite are found to pass through this substance, which must not be accepted as only appearing in the finer form used for slates, but also in coarse and thick schisti, and sometimes, though rarely, even massive.

Potosi.

It is doubtful whether the yellow argillaceous schistus, which composes the famous mountain of Potosi, belongs to this description; as the argillaceous schistus, or the clay-slate of many other countries, so remarkably metalliferous, cannot be classed under this division; which further evinces the utility, if not necessity, of a far greater abundance of definitive denominations in this new science. But Helms seems to consider the Andes as chiefly composed of what Kirwan calls *primeval blue argillite;* and he describes the yellow slate of Potosi as being extremely hard. If they contain from 10 to 20 of iron, they belong to this division; and as iron commonly accompanies the richest ores, it is probable that its presence is here indicated. But Humboldt regards that amazing chain of mountains as chiefly composed of what is called argillaceous porphyry; while those of New Spain are of argillaceous schistus: roofing-slate, and its correlatives, being regarded as rare.

Quarries.

There are valuable quarries of slate in Cornwall, Wales, Westmoreland, and Scotland. A curious account of the manner of working those of France, near Angers, may be found in the *Journal des Mines.*

In his account of the primitive schisti, Patrin has the following article*:

Slate of Ural.

"*Ferruginous schistus.* This slate is mostly composed of hardened clay, abundantly mingled with an oxyd of iron, either black or brown, sometimes red or yellow; a little quartz; and much mica. This rock is one of the most common in the northern countries, where iron is singularly abundant. The eastern part of the Uralian chain of mountains, for an extent of about 500 leagues from north to south, is almost entirely composed of this rock."

The same able author gives the following account of the slate-mines at Charleville on the Meuse, which he regards as primitive; and afterwards of those of Angers, considered by him as secondary.

"The slate-mines of Charleville are not explored by open quarries, like those of secondary slate, but by subterranean galleries, because the roof of the bed of slate is composed of banks of quartzose schistus, very hard and very thick; and besides, the slate plunges very rapidly under this rock, which would render enormous clearages necessary, and would expose the workmen to great danger from falls of the rock.

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* i. 120.

"The principal slate-mine of this country is that of Rimogne, four leagues to the west of Charleville. It is in a hill, of which the centre is primitive, but the skirts are in part covered with beds containing shells. The mouth of the mine is towards the summit; the bed explored inclines forty degrees to the horizon, so that to advance four feet, you must descend about three feet perpendicular. The workmen call this bed the plate, on account of its form, which is flat and thin, if the extent be considered. Its thickness is nevertheless sixty feet; but its length and breadth are incomparably greater, and their limits remain unknown. It has been pursued, by a principal gallery, to the depth of 400 feet; and they have driven many lateral galleries, which are prolonged about two hundred feet, on each side of the main gallery; where are placed, in succession, twenty-six ladders, for the passage of the workmen, and the carriage of the slate.

"But in this thickness of 60 feet, there are only 40 of good slate: the remaining 20 of the underpart are full of quartz, and unmanageable. The rock, which forms the immediate roof of the of slate, chiefly near Laferriere in Normandy, and in the neighbourhood of Angers. The last is the most important; it furnishes slate of the most perfect quality; and its extent and prodigious thickness make it be regarded as inexhaustible.

"This bed extends for a space of two leagues, from Avrillè to Trèlazè, passing under Angers, where the Mayenne, which comes from the north, cuts it at right angles.

"The town of Angers is not only covered but built with slate, those blocks being employed in masonry which are the least divisible.

"The quarries which are actually explored are all in the same line, from west to east, as well as the ancient pits; it being in this direction that, by the exterior disposition of the soil, the bed of slate presents itself nearest the surface. Immediately under the vegetable earth is found a brittle kind of slate, which, for four or five feet in depth, splits into little fragments of some inches, which have the form of a rhomboid, or a portion of that figure.

"A little lower is found what they call building stone, being a pretty firm slate, but scarcely divisible into leaves. This is employed in the construction of houses, after it has been sufficiently hardened by being dried in the open air.

"At fourteen or fifteen feet from the surface is found the good slate, which has been quarried to the perpendicular depth of about 300 feet, the remaining thickness being unknown.

"The operations are conducted by open quarries, by successive *foncées;* trenches, of about nine feet deep, gradually narrowed, in order to preserve a slope sufficient to prevent lapses of the rock; so that a trench, four hundred feet in width at the opening of the quarry, shall be reduced to nothing at the thirtieth *foncée*, that is the depth of 270 feet. There is every reason to presume that a far greater depth might be attained, and with more advantage, as the lower they have gone the more perfect is the slate. They have only been stopped by the difficulties presented by the method of quarrying hitherto adopted, which appears not to have been the best, in one respect particularly, which is, that the quantity of slate diminishes as the quality becomes better, so that in the total mass those of a middling quality are far more numerous. It would seem that the method of subterranean galleries would prevent the inconveniencies of the present plan; there would not at least be lost and overwhelmed a prodigious quantity of excellent slate. The slate-mines of Charleville might serve as an example; where, in spite of the disadvantageous situation of the bed, which renders it more difficult to be worked than if it were horizontal, the product amply repays the undertakers, though the galleries be of great length, and some even pass under the river Meuse. Slate is far more valuable than coal; and yet all mines of the latter are explored by pits and galleries, sometimes of immense depth: those of Charleroi, in the Netherlands, are about two thousand four hundred feet in perpendicular depth; those of Whitehaven, in England, about five thousand, while they extend more than half a league under the sea. But works conducted with skill overcome the difficulties which are produced by these subterraneous excavations, which are repaid with great profit, and no part of the mineral treasure is lost. It would therefore be of great consequence to try if the method of galleries could not be adopted at Angers.

" As to the interior structure of this great mass of slate, it is divided by many veins of calcareous spar and quartz, about two feet thick, by fifteen or sixteen in height; they are parallel amongst themselves, and proceed regularly from west to east, in a situation which approaches the vertical, as they only decline seventy degrees towards the south. These veins are met at intervals by similar veins, whose direction is the same; and of which the inclination is also seventy degrees, but in an opposite sense, so that when they meet the former they either form rhombs, or half rhombs, which Guettard compares to the letter V; some being upright, while others are reversed.

"All the layers or leaves of the slate have a direction and inclination similar to those of the first veins of quartz; that is to say, that they rise seventy degrees towards the south, and dip towards the north: and even when intersected by veins which have an opposite inclination, theirs is not changed. The whole mass is thus divided into immense rhomboids, composed of plates all parallel amongst themselves, and with the two opposite faces of the rhomboid.

"The slate of Angers is extracted in blocks of a fixed size, which are divided, as at Charleville, into *repartons* and leaves. It is betwixt these leaves that there are frequently found vestiges of marine animals, and above all pyritous impressions of *pous-de-mer* (the sea-louse, a little univalve shell of the courie kind); of little *chevrettes* (shrimps or prawns); and a kind of crab, of which the body is about a foot in breadth, and fourteen or fifteen inches in length, the tail having nine or ten rings. The shrimps are sometimes so numerous, that Guettard counted forty upon a slate of only one foot square. But it must be observed that none of the above animals have similar representatives in living zoology. But what appears most surprising in these impressions, particularly with regard to the large crabs, is, that the body, though there be no sign of its being crushed, may be said to have no thickness whatever. They are rather simple engravings than bodies in relievo, the convexity of these large crabs upon a thin leaf of slate not exceeding the quarter, or even the tenth part, of a line; nor is it perceivable that the body of the animal at all penetrates the thickness of the leaf where it is adherent. And what still adds to this wonder, is the nearly vertical situation in which these impressions are found in the mine.

"A series of leaves of slate may be compared to a set of books placed upon shelves; and the impressions of crabs and other animals, to engraved plates in the volumes. They do not, in fact, occupy more thickness; and it is equally difficult to conceive how the body of these animals, though otherwise perfectly defined, should be reduced to a simple surface without thickness: and how it should always be found in a vertical situation, which cannot be ascribed to any derangement in the bed itself, since it is still horizontal, and occupies a space of many leagues. The difficulty of supplying such phenomena has led some to imagine a plastic force in nature, a power of modelling, in the mineral kingdom, forms analogous to those of organised bodies.

" These slates also often present beautiful pyrites in the form of trees, more than a foot in extent, which are regarded by Guettard as impressions of *tremellæ*. The pyrites is sometimes in small grains, disseminated like a dust upon the surface of the slates; where may also be observed many little stars of selenite.

" When the blocks have been drawn from the quarry, if they be left exposed to the sun or to the open air for some days, they lose what is called the *quarry-water*, become hard and untractable, so that they can only be employed in building. Frost produces a singular effect on these blocks: while frozen they may be divided with more ease than before; but if thawed a little quickly, they are no longer divisible. Yet this quality may be restored by exposing them once more to frost; but if the alternative be often repeated, it becomes impossible to reduce them to leaves.

" The secondary slate which is found in other countries, offers nearly the same dispositions and phenomena as that of Angers. It is a substance as rare in other countries as in France, there being only one or two quarries in England, in the county of Caernarvon. Switzerland presents no slate, except in the valley of Sernst, in the canton of Glaris.

"Italy has only one slate-quarry, that of Lavagna, in the state of Genoa, which furnishes a slate of an excellent quality, and so impenetrable to fluids, that it serves to line the cisterns in which olive-oil is preserved.

"Germany presents many kinds of secondary slate (clay-slate), containing impressions of reptiles, fish, and other animals; but these impressions have a considerable relievo, and it is evident that the animal has existed. The most remarkable of these slate-quarries are those of Eisleben, in Saxony; of Ilmenau; of Mansfeld, in Thuringia; and of Pappenheim, in Franconia. I have often seen, in the mountains of Siberia, beds of primitive slate, more or less considerable; but they are mostly aluminous, and furnish the *kamennoie maslo*, or rock butter, a fat yellowish substance of a penetrating smell, being a mixture of alum and fluid bitumen. But I have no knowledge that in all this immense country there is one bed of secondary slate. Nor does Bowles, in his Natural History of Spain, indicate that he has observed any in that kingdom*."

To these accounts may be subjoined a short description of a remarkable quarry in Cornwall, unknown to Patrin.

"Between Liskeard and the Tamar, on the south-west, are some quarries of slate, which supply the inhabitants of Plymouth with covering for their houses, and for the purpose of exportation. Several quarries have also been opened at other places; but the best covering-slate in Cornwall, or perhaps in England, is procured at Denyball, nearly two miles south of Tintagel, in the north part of the county. The whole quarry is about 300 yards long, 100 broad, and almost 40 fathoms in depth. The slate-rock is disposed in strata, dipping to the south-west, and preserving that inclination from top to bottom. It is first met with at about three feet below the surface of the ground, in a loose, shattery state, with short and frequent fissures; the laminæ of unequal thickness, but not horizontal. Thus it continues to the depth of ten or twelve fathoms, when a more firm and useful stone is procured, the largest pieces of which are used for flat pavements. This is called the top-stone, and continues for ten fathoms; after which the quality improves with the increasing depth, till, at the twenty-fourth fathom from the surface, the workmen arrive at the most superior kind, called the bottom-stone. The colour is grey blue; and the texture is so close, that it will sound like a piece of metal. The masses are separated from the rock by wedges, driven by sledges of iron, and contain from five to fourteen superficial square feet of stone.

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* Patrin Min. iii. 307.

"As soon as this mass is freed by one man, another stone-cutter, with a strong wide chisel and mallet, is ready to cleave it to its proper thinness, which is usually about one eighth of an inch: the pieces are generally from a foot square to two feet long, by one wide; but the flakes are sometimes large enough for tables and tomb-stones*."

STRUCTURE I. COMMON.

Aspect 1. Ash grey slate, from Angers, in France.

Bluish grey slate, from Westmorland.

Purple or reddish purple slate, from Anglesea.

The same, with pyrites, &c.

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* Brayley's Beauties of England, ii. 329.

Aspect 2. Killas, from Cornwall, many varieties; blue, grey, or whitish yellow. If it contain only 6 of iron, it belongs to the argillaceous or to the magnesian schisti.

STRUCTURE II. MASSIVE.

The same identic substance of which slate is composed has been discovered in France, and other countries, in a massive form, or stratified with the seams at great distances, and incapable of being split into thin plates, like common slate. It may probably be often discovered in the vicinity of slate-quarries.

The slate with impressions so frequently found with coal, and called shale, is commonly of an earthy texture, and belongs to clay-slate.

Saussure mentions slate in columns like basalt*. He also enumerates the following:

§ 598. Granite, joined with slate; the last being composed of mica and *pierre de corne.*

§ 1862. A slate, with mica, in leaves thinner than paper, sometimes straight, sometimes undulated. It is, according to Saussure, a mixture of ferruginous clay and mica.

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* i. p. 523, 4to.

§2122. On the passage of Simplon an intermediate slate, between the mica and the common, of a brilliant and undulated appearance, containing garnets.

MODE XIII. MICA SLATE.

Arrangement. It is difficult properly to arrange mica slate. Though it contain a great quantity of quartz, it has always been classed among the argillaceous substances, as the mica is the chief characteristic. Mica sometimes contains no magnesia; but according to the analyses given by Haüy, the brown, grey, or black, which are the most abundant and common in mica slate, contain a greater portion of iron than of argil, the quantity of potash being also considerable. Bergman found 9 parts of iron in mica; Kirwan nearly 20: even of the colourless kind Klaproth discovered 15 in one sort, and 22 in another.

Connexions. Mica slate has also a natural connexion with common slate, into which it often passes*. It must also be observed that Saussure found in the

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* Daubuisson's curious and elaborate analysis (Jour. de Ph. 1809) proves, that the composition of mica slate and slate is identically the same. The *mode* forms the only difference.

Alps rocks in which scales of iron supplied the place of mica. In all events the black mica must belong to the siderous division; while the white mica, which might be called micarel, and sometimes passes into steatite, ought to be classed among the magnesian substances*.

Mica slate has a further affinity with the siderous substances, as, like siderite, it frequently contains garnets. It is very metalliferous, many of the mines of Norway and Sweden, and a part of those of Saxony and Hungary, being situated in this rock.

STRUCTURE I. REGULAR.

Mica slate of a jet black, with black quartz, from Switzerland.

Grey mica slate from Scotland, where it abounds in the Grampian Mountains and some of the isles; not to mention innumerable other regions.

Grey mica slate, used for ovens (Stellstein), from Sweden. Wall. i. 427.

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[*] Kirwan has called the brownish black mica *micarelle*, because it contains *no magnesia!* Klaproth found in it:

0063	argil
295	silex
675	iron
1033	

In very thin plates, and of an almost impalpable grain, from Scotland.

Brown mica slate, from the same countries.

The green and white need not be here specified.

STRUCTURE II. IRREGULAR.

The noted *hornberg* of the Swedes belongs to this division, being a coarse mica slate irregularly contorted. It is very metalliferous*. As it is a celebrated rock with a barbarous appellation, it may be called Linnite, in honour of Linnæus, a native of Sweden, who however contributed but little to its mineralogy.

Linnite, from Sweden.

The same, from Norway.

STRUCTURE III. MINGLED.

When mica slate is mingled with garnets, it constitutes the Murkstein, or Norka, of the Swedes, and the latter name might be retained, if requisite; but garnets form so common an adjunct of mica slate, that the distinction seems unnecessary.

Mica slate, with garnets, from innumerable countries.

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* See *Journal des Mines*, No. 88, p. 257. It is granular, blackish, with thick and short layers.

The same, with schorl, from the Grampians.

The same, with sappare, the kyanite of Werner, from the mainland of Shetland, and from Aberdeenshire*.

The same, with various ores.

Saussure mentions the following varieties:

A rock of reddish mica slate, of which the leaves, being often curved, present at intervals quartz in the form of lentiles, but often some inches in length, and one or two in thickness. § 1366.

A remarkable mica slate, composed of thin white and grey leaves, so as to appear on the sides like a striped stuff; the grey part being mica, and the white a very fine arenaceous quartz. § 1474.

A gneiss, composed of jad and siderite; his jad being probably compact felspar. § 1331.

A part of the chain of Mont Blanc consists of a hard ferruginous quartz, mixed with mica. § 847.

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* Sappare is the ancient Scotish name, retained by Saussure, who informs us that he first received the substance from the duke of Gordon. Werner's alteration is alike useless and absurd, the original appellation implying its similarity to sapphire, for which it has sometimes been substituted by jewellers.

MODE XIV. SIDEROMAGNESIAN ROCKS.

These rocks are far from being uncommon among primitive mountains, being chiefly composed of magnesia and oxyd of iron. In the substance called chlorite by Werner, from its green colour, the iron often exceeds forty parts in the hundred; and it is even used as an ore of that metal. Of actinote[*], by some called actynolite, some kinds contain as much iron as is found in siderite; and it is in general considered as only a different structure of that rock. Saussure indeed regarded chlorite as only a kind of earthy siderite; but as it contains a far greater portion of magnesia than siderite, in which that substance is scarcely recognisable, it seems more proper to allot to these rocks an article apart: and the chemical *mode of combination* is at least very different.

Chlorite and actinote.

To this Mode may also be added another mixture of iron and magnesia, those serpentines which contain so great a portion of iron as to affect the magnet. Most of the siderous rocks consist of iron and clay. The eisenkesel, that is

Some serpentines.

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[*] From the Greek *ακτινοτος*, *radiated*, so that the *y* is foreign to the orthography.

the iron-flint, of Werner, is merely a vein-stone, and never appears in the shape of a rock; and generally the silex in siderous substances is lost in the argil. The *sidero-calcite* and *ferri-calcite* of Kirwan have little connexion with the present subject, the former being pearl-spar, the latter only embracing a few lime-stones, which contain from 10 to 20 of iron; but as they easily decompose, present no remarkable variety, and are little interesting, it is unnecessary to distinguish them, except as mere diversities of lime-stone. Innumerable marbles are tinged with iron, from which they chiefly derive their colours; but it would be a too nice and useless distinction to compose an arrangement from this mere accidence, which varies in different parts of the same rock. There remain therefore only the magnesian rocks to be specially considered in their conjunction with iron, a metal with which they have often a singular affinity.

STRUCTURE I. CHLORITE.

This substance is by Werner divided into four kinds; chlorite earth, common or compact chlorite, foliated chlorite, and chlorite slate. It seems unknown to Wallerius, who published his last edition in 1772; but is the green talc of Born, and the Samnterd of old German writers, perhaps from its velvety appearance. To the Cornish miners, as it often occurs with tin, it is also known by the name of *peach**.

The first Aspect, that of chlorite earth, can scarcely be said to form a rock, chiefly occurring in clay-slate, and probably forming the green nodules in basaltin. The second kind is perhaps unknown, save as a vein-stone; and what is called the foliated is generally crystallised, being found at St. Gothard with other crystals. The only rock therefore of the kind is:

Aspect 1. Chlorite slate. Texture, finely granulated, sometimes regularly, sometimes irregularly; schistose, so that fragments sometimes assume the form of a wedge.

Hardness, gypsic. Fracture, sometimes even, or undulating, or scaly. Fragments, slaty, blunt, except when mixed with quartz.

Weight, sometimes granitose, sometimes carbonose.

Lustre, glistening, somewhat resinous. Opake.

Chlorite slate, from Egypt. Wad, 23, a small statue.

Chlorite slate, from Corsica, Norway, Sweden,

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* It is the *baldogea* of Saussure, so called from Monte Baldo.

Stiria, Tyrol, Scotland, &c. It is generally sprinkled with octaedral crystals of iron, and sometimes with garnets. The first are the most characteristic of this rock.

Chlorite slate, mixed with quartz. This kind is commonly even schistose, but far more hard than the former.

Saussure, § 2264, expresses great surprise, when, on receiving specimens of the chlorite slate of Werner, he observed that there was scarcely any chlorite in them; and he adds, that the denomination being quite deceitful, it ought to be changed.

On the lofty summit called the Col du Géant, Saussure found that the granite, like that which is greatly elevated at Mont Blanc, can scarcely be said to contain mica. Here its place was often supplied by a small-grained chlorite*.

STRUCTURE II. ACTINOTE.

This substance also chiefly occurs in small portions. It is the strahlstein of the Germans, and is by Werner divided into the asbestoid, the common, and the glassy. Of these it is believed the

Glassy actinote.

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* Sauss. § 204.

last only appears in the form of rocks. Saussure, who calls it delphinite, or green schorl of Dauphiny, describes a rock of this kind. He also mentions smaller portions of a compact kind.

That the glassy actinote strictly belongs to the siderous domain, will appear by the analysis of Vauquelin; silex 37, argil 21, lime 15, oxyd of iron 24, with a small portion of manganese*.

Texture, sometimes massive, but generally in thin six-sided acicular crystals.

Hardness, between marmoric and basaltic. Fracture, fibrous and radiated. Fragments, splintery and very sharp.

Weight, siderose.

Lustre, shining and glassy; strongly translucent.

Actinote, from Switzerland, where, as has been mentioned, it forms entire rocks.

STRUCTURE III. SIDEROUS SERPENTINE.

Of this kind Humboldt discovered a curious rock with magnetic power, forming the mountain of Regelberg, in Germany; the south side attracting the north pole, and the northern side the south pole.

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* Lametherie observes, that the earthy smell shows an approximation to hornblende. Th. de la Terre, ii. 373. Is not schorl a black actinote?

Rocks of the same kind may probably be discovered in other countries; at any rate many serpentines are so replete with iron as to fall into this division.

Saussure, § 1342, gives a minute description of what he calls granular serpentine. It is so much impregnated with iron, that it belongs to the sideromagnesian rocks.

The mountain called Roth Horn is in a great part composed of compact serpentine, semi-hard, that is, of the hardness of marble. It is called the Red Horn, because the serpentine, though green within, is red on the surface, from the oxydation of the iron*.

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* Sauss. § 2157.

spar, or rather felsite; for Werner has pronounced that the felspar in the ancient porphyries is compact.

The variolites of Turin are of a brownish grey, of a shining and unctuous appearance, with spots of a lighter grey, and white starry crystals. The variolite of Sesia is of a reddish grey, with spots of a bright brick red.

Saussure mentions, § 1289, a kind of soft variolite, seemingly composed of green siderite, with spots of white felspar, sometimes rhomboidal, sometimes circular.

STRUCTURE II. IRON-STONE WITH IMBEDDED CRYSTALS.

Iron-stone, with crystals of quartz, from the Surry hills.

Saussure mentions, § 1322, a red and green porphyry, or rather intrite, mixed with felspar and actinote; the base being of granular felspar.

MODE XVI. SIDEROUS GLUTENITE.

Glutenites, how classed.

In arranging these substances, two objects are to be considered; the nature of the fragments or particles cemented, and that of the cement itself. When they are both of one kind, as a siliceous bricia*, or a pudding-stone with a siliceous cement, there can arise no doubt concerning their classification: but when, as often happens, the fragments are of one kind, and the cement of another, the domain may appear doubtful. The more general method however appears to have been, to denominate the substances from the cement, as being the predominating agent; and this rule is particularly applicable in the present instance, as oxyd of iron forms the strongest of natural cements. Bricias of basaltin or jasper are commonly cemented by the same substance, and sometimes, though rarely, by quartz; but they may still be referred to the predominating substance, the quartz being common, and of inferior consideration.

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* This word is strictly Italian; *bricia*, a crumb or small fragment, with its derivatives *briciolatta*, a little crumb, *briciolino*, and *briciolo*. Breccia is only a corruption.

The Italian architects and statuaries gave the first modern classical names to rocks, as *granito*, *granitone*, *granitino*, &c. &c.

Bricias and pudding-stones.

The division of glutenites into bricias and pudding-stones, the former consisting of angular fragments, the latter of round or oval pebbles, would not be unadvisable, were it in strict conformity with nature. But there are many rocks of this kind; as, for example, the celebrated Egyptian bricia, in which the fragments are partly round and partly angular*; while the term glutenite is liable to no such objections, and the several structures identify the various substances.

English pudding-stone.

The celebrated English pudding-stone, found no where in the world but in Hertfordshire, appears to me to be rather an original rock, formed in the manner of amygdalites, because the pebbles do not seem to have been rolled by water, which would have worn off the substances in various directions; while, on the contrary, the white, black, brown, or red circlets, are always entire, and parallel with the surface, like those of agates. Pebbles therefore, instead of being united to form such rocks, may, in many circumstances, proceed from their decomposition;

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* So also the celebrated pudding-stone of England. See Anomalous Rocks.

the circumjacent sand also arising from the decomposition of the cement.

Mountains or regions of real glutenite often, however, accompany the skirts of extensive chains of mountains, as on the north-west and south-east sides of the Grampian mountains, in Scotland, in which instance the cement is affirmed by many travellers to be ferruginous, or sometimes argillaceous. The largeness or minuteness of the pebbles or particles cannot be said to alter the nature of the substance; so that a fine sandstone is also a glutenite, if viewed by the microscope. They may be divided into two structures: the large-grained, comprising bricias and pudding-stones; and the small-grained, or sandstones. Sites.

STRUCTURE I. LARGE-GRAINED GLUTENITES.

Siderous glutenite, or pudding-stone, from Dunstafnage, in Scotland, where it forms romantic rocks of a singularly abrupt appearance, in some parts resembling walls. The kernels consist of white quartz, with green or black trap, porphyries, and basaltins.

Glutenite, from the south of the Grampians, from Ayrshire, from Inglestone bridge, on the road between Edinburgh and Lanark. But of these the cement is often siliceous, as in those at the foot of the Alps, observed by Saussure. The siderous glutenites commonly originate from the decomposition of siderous rocks, which also afforded the cement.

Glutenite, consisting of fragments of granite, cemented by trap.

Siderous glutenite, or pudding-stone of the most modern formation. This is formed around cannons, pistols, and other instruments of iron, by the sand of the sea.

Glutenite of small quartz pebbles, in a red ferruginous cement, found in the coal-mines near Bristol, &c.

Basaltic bricia, from Arthur's Seat, near Edinburgh.

Porphyritic bricia (*Linn. a Gmelin,* 247), from Dalecarlia in Sweden, and Saxony. Calton-hill, Edinburgh?

STRUCTURE II. SMALL-GRAINED.

Rothe todt liegendes.

Aspect 1. The most remarkable of the siderous sand-stones, is that celebrated by the German geologists under the appellation, given by the miners, of *Rothe todt liegendes,* or the *red and dead layer,* so called from its colour, and because it is wholly unproductive, no minerals being found in or under it. This singular rock has been termed *semiprotolite* by Mr. Kirwan, implying that it is half primitive; and he informs us that it is commonly found under coal, is micaceous, and contains lumps of porphyry or granite. The grains are generally quartz or keralite, the cement being an irony clay, which imparts the colour.

But as the passage affords some curious German learning on the subject, from books little known in this country, it shall be presented entire.

"*Semiprotolites (Rothe todt liegendes)*.

"These stones I call by this name, as being partly of primeval, and partly of subsequent, origin: they consist of pebbles, or of fragments, or of sand of primeval origin, compacted and cemented by an argillaceous, or calcareous, or siliceous cement, of posterior origin; hence they generally form the lowest stratum that separates primeval rocks and secondary strata. From their composition, they come under the denomination either of farcilites, brecias, or sand-stones. In some places this sand has been accumulated into vast heaps, so as to form mountains 6 or 700 feet high, and then compacted by an adventitious cement. Of this sort are the mountains of Hertzberg and Kaulberg, near Ilefeld, in which the sand is cemented by a ferruginous cement, and contains fragments of porphyry, and also veins of iron-stone, and manganese, and strata of coal, with impressions of reeds, rushes, and other plants, Lasius, 249 and 280. The red colour is evidently from iron.

"The semiprotolite of Wartburg, near Eisenach, contains rounded lumps of granite and schistose mica: substances found in the neighbouring mountains. The semiprotolite of Goldlauter consists entirely of porphyry, as do the primeval mountains of that district. That of Kiffhauserberg, in Thuringia, contains rounded argillites from the neighbouring mountains of the Hartz. Petrified wood is found in this last, Voigt's Letters, 19, 20. According to Voigt, the semiprotolite found under coal has a siliceous cement, and contains few primitive stones; Lettres sur les Montagnes, 31. Saussure made the same observation on those which he found on the descent of Trient, which interceded between the primary and secondary mountains, 2 Sauss. § 699. He even remarked long before, that primeval and secondary rocks were almost always separated by a sand-stone or farcilite, 1 Sauss. § 594. Where the secondary strata are calcareous, the semiprotolite has a calcareous cement; see Lehm. 168. Semiprotolite is always red, by reason of the ferruginous particles by which it is cemented; its diffusion or expansion is unequal, being frequently horizontal or even, but sometimes depressed, and in other instances much elevated. Most of the superimposed strata partake of this inequality, and are its natural consequences. Hence the protuberances and depressions, otherwise called moulds, observed in them; Charp. Saxony, 371. It rests on granite, Ibid. 370, 371."*

Mr. Jameson informs us that in the Hartz it rests on grauwack, and extends nearly round the whole of the country; nay, through Saxony, Hessia, Bohemia, Silesia, and Franconia. The red sandstone of the north of England, which is micaceous, and often regularly schistose, so as to form pavements, &c. seems also to belong to this formation. As the substance is widely spread and highly remarkable, the barbarous denomination may be exchanged for that of Lasite, in honour of Lasius, the celebrated describer of the Hartz, who has ably illustrated this substance.

Lasite, of various kinds, from Germany, of which there is a series at the College des Mines, in Paris, where it was shown to me by Daubuisson.

The same, from the north of England, &c. &c.

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* Kirwan Geol. Essays, 256.

Aspect 2. Ferruginous sand-stone, of a light brown, with glandules and veins of a deeper colour, from Mont Calvaire, near Paris, where it is frequent in ferruginous sand, probably arising from its decomposition.

A ferruginous sand-stone, mentioned by Mr. Kirwan, afforded 19 parts of iron in the 100. The *Eisensanderz*, or iron sand-stone of the Germans, is of this kind, and is sometimes worked as an ore of iron.

In the Vosges mountains the summits are often of ferruginous sand-stone, resting on granite*. Dietrich, as already mentioned, thinks that red sand-stone is as primitive as granite itself.

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* Dietrich, Sivry, &c. Saussure says, § 699, that the deadlyer of the Germans, or rather deadlayer, is a pudding-stone.

Mont Blanc.

DOMAIN II.

SILICEOUS.

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SILEX, SILICA, OR SILICEOUS EARTH.

THIS earth derives its name from the silex, or flint, in which it abounds. Some also denominate it quartzose earth, because it is perhaps more abundant in the stone called quartz, which, when transparent and crystallised, is styled rock crystal. It so frequently occurs in the form of sand, which covers a great part of the globe, either alone or mixed with clay, that late chemists infer that such sand arises not only from the decomposition of rocks, but is often a disturbed or hasty crystallisation of silica*. This is further confirmed by the circumstance that many primitive mountains consist of granular quartz, of an arenaceous appearance, like agglutinated sand.

The stones now called siliceous, were formerly denominated vitrifiable; because, with an alkali, they may be melted into glass; and the finest Venetian glass was fabricated from quartz, by the Italians called *tarso*†. Silica, like the other simple earths, is a fine white powder; but the particles have a harsh feel, like minute sand. Alone it is scarcely fusible; but when newly precipitated, is soluble in 1000 parts of water.

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* The purity of this term may be doubted. *Alumina* is ridiculous, being the plural of *alumen*. In the fabrication of new words grammatical precision ought always to be studied.

† In the Phil. Trans. 1683, Dr. Lister says *tarso* is the quartzose sand of which the fine Venetian glass was made. The same ingenious author there proposes, p. 739, Mineral Maps of Counties, as he calls them.

Joined with iron, argil, and magnesia, it constitutes the primitive and most important rocks, rising to the regions of perpetual snow, and thus supplying unfailing aliment to the great rivers that fertilise the earth. When considered in these mountains, in sand, and in clay, it may be pronounced the most abundant of all the earths: and *if* iron form the nucleus, the shell of this planet may be said to consist chiefly of silex. It is suspected that it is coeval and intimately connected with iron; as the aerolites or meteoric stones, and the large masses of native iron, discovered in Siberia and South America, contain abundance of silex mixed with some magnesia*.

Siliceous substances generally strike fire with steel; and flint or quartz yields a peculiar odour, supposed by some to arise from a subtile substance which chemistry has not been able to discover. A strong phosphorescence is also produced by collision, so that, during Alpine hurricanes, the torrents, rolling large fragments of rock, present a singular scene of corruscation.

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* Chrysolite, a mixture of silex and magnesia, is always found in native iron. The exclamation of Henkel is well known:

O silex! silex! quæ te matercula gessit?

MODE I. QUARTZ.

Distinctive characters.

Texture, compact, generally uniform, sometimes granular, rarely laminar, in which form the lustre is generally dull.

Hardness, crystallic. Fracture, splintery, but such as sometimes to resemble the conchoidal. Fragments, very sharp.

Weight, granitose.

Lustre, glistening or shining, sometimes unctuous. From transparent to opake.

Colour, generally white; sometimes brown, grey, yellow, red, or black.

It sometimes composes entire mountains, and abounds in those of granite, in which substance it is seldom crystallised.

STRUCTURE I. COMPACT.

Aspect 1. Opake. A very common substance, but the specimens of entire mountains are rare.

Sites.

"The mountain of Kultuck, on the south-west end of the lake Baikal, 350 feet high, and 4800 long, and still broader, consists entirely of milk-white quartz: per Laxman, 1 Chy. An. 1785, 265. Also Flinzberg, in Lusatia, almost entirely. 2 Berg. Jour. 1789, 1054. There is also an extensive narrow ridge of quartz, some miles long, in Bavaria. 2 Berg. Jour. 1790, 529, &c. Flurl Bavaria, 309. Monnet mentions a rock of quartz 60 feet high. 17 Roz. 163. Mountains of it also occur in Thuringia. Voigt Prack. 69. and in Silesia. Gerh. Beytr. 87. and in Saxony. 1 Berg. Jour. 1788, 269. and in layers between gneiss and slate mica. 2 Lenz. Also in Scotland. 2 Wms. 52. It is not metalliferous. Werner Kurse Classif. 15. Petrol is often found in it. 1 Berg. Jour. 1791, 91. The mountain of Swetlaia Gora, among the Uralian, consists of round grains of quartz, white and transparent, and of the size of a pea, united without any cement. 2 Herm. 278*."

Mountains of quartz also occur in Scotland, where, from the white substance, they sometimes appear as if covered with snow. A hill of this kind is seen near Cullen, which supplies glass-works at Newcastle with quartz. The mountains of Scuraben and Morven, in Caithness, are chiefly constituted of this substance; which also, according to Mr. Jameson, occurs in great quantity in the islands of Ilay, Jura, and Coll. There are also large rocks of quartz in Upper Lorn. Buffon says*, there is in Auvergne, near Salvert, a vein of quartz 10,000 fathoms in length.

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* Kirwan Geol. Ess. 179.

In the Uralian mountains it sometimes happens that there is an entire mountain of quartz, another of felspar, and a third of talc, thus presenting the materials of granite on a very large scale.

Aspect 2. Semi-transparent. This sometimes forms very extensive veins, but perhaps never constitutes an entire hill or rock.

Aspect 3. Unctuous. This also appears in veins, and generally accompanies metals.

STRUCTURE II. GRANULAR.

This kind often constitutes entire mountains in Scotland, and other parts of the world. It has sometimes been confounded with siliceous sandstone, but late writers have demonstrated that it may be owing to a primitive but disturbed crystallisation†. Nor is it inconsistent that where the cement was deficient or interrupted, it should appear among the most ancient substances in the shape of mere sand. The grains, as already mentioned, are sometimes of the size of peas.

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* Min. i. 100.

† Collate however the account of the Siliceous Sand-stones, Mode XIV. Str. 2.

Grey granular quartz, from Balahulish, in Scotland.

The same, with veins of white semi-transparent quartz, from Bunessan, Mull.

Saussure describes, § 999, rocks of a beautiful granular quartz, which rises in leaves of a rhomboidal form. It is very hard, and has the grain and whiteness of statuary marble.

Veins in lime-stone.

He also observes, § 2235, that in primitive limestone there are often veins of quartz, as there are also veins of keralite or hornstein in compact limestone. Query, if both the latter substances do not contain more argil?

Mr. Playfair observes that granular quartz is common in Scotland, alternating with schisti, particularly on the north side of the harbour of Balahulish, and on the sea-shore at Cullen. He also shows that sand is a crystallisation; and mentions a siliceous grit with no cement*.

In Buckinghamshire, Wiltshire, and Dorsetshire, where there are only sand and chalk, there is found in the sand a prodigious number of large blocks of granular quartz, which is used for paving or building. The castle of Windsor, and the terrace, are built of this stone, probably from the forest, or the neighbouring heaths, where there is a great quantity; and Stonehenge is built of these blocks. So blocks of granite are found in Brandenburg, Mecklenburg, and Pomerania*.

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* Hutt. Theory, 27, 171, &c.

Mountains of granular quartz abound in Scotland; and granitic mountains in Sweden. When the continents were gradually emerging, and before these large subsidences which form mediterranean seas, it may easily be conceived that the plains where such blocks, and gravel foreign to the surrounding mountains, are always found, were covered for ages by the waters of the ocean, which rolled these blocks and gravel in the direction of their currents.

In a late volume of the Philosophical Transactions†, Bournon gives some observations on the different modes of attraction, which influence the formation of minerals. The attractions of aggregation are either simple or crystalline.

"It sometimes happens (owing perhaps to a more considerable degree of disturbance during the process of attraction), that there are found small irregular detached masses, often so minute as to be scarcely perceptible; at other times they are of a larger size, and, as soon as formed, fall to the bottom of the liquor, and unite together by a simple mode of attraction, which may with great propriety be called *simple homogeneous attraction of aggregation*. Of this kind are, granulated quartz, granulated carbonate of lime, &c. the different kinds of which substances differ from each other only by the fineness or coarseness of their grain."

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* De Luc, Geologie. Paris 1809, 8vo. p. 332.

† 1804, p. 37.

Sometimes this takes place along with the crystalline, whence small crystals, &c. Sometimes the molecules are precipitated in a detached but confused manner, so as to form earthy or compact substances. In aggregate stones there is the attraction of aggregation, as in granite, sandstone, and others.

But long before, Mr. Kirwan* had made the following observations:

"The first step in the process of crystallisation is the formation of grains; the second is the increase in one dimension; the third in two dimensions; and the fourth in three dimensions: the grains themselves, however, to be visible, must receive accretions in the three dimensions. If the process be uninterrupted, no traces of distinction will be perceived, and the whole will appear perfectly uniform; but, if it be disturbed in the first step, no crystallisation can take place; if in the second, the grains will appear distinct, small or gross, coarse or fine, according to the nature of the disturbance, whether by the interruption of the process, or the accession of foreign matter; this latter generally produces coarse or rude grains, in proportion to the quantity.

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* Min. i. 81, edit. 1794.

"If the disturbance only takes place in the third stage, we shall have fibres or striæ, as complete surfaces cannot be formed; the striæ having more extension in breadth than the fibres or filaments, argue a smaller degree of disturbance than the mere fibrous appearance.

"If, during the third stage, the striæ be forced into contact by the gradual dereliction of the fluid that kept them suspended, they will form lamellæ in proportion as they are deserted, which will either adhere to each other, and then fall confusedly, being too heavy to be supported by the menstruum, or, if supported, will be superimposed on each other.

"But if the process of crystallisation be disturbed only in the fourth stage, then the form and shape only of the crystals will be more or less altered.

"All these steps are noticed and described by chemical writers; and particularly by the celebrated Rouelle, in the Memoirs of the Academy of Paris on the crystallisation of salts."

STRUCTURE III. LAMINAR.

This is generally dull, and approaches to the next Mode, keralite, or rock-flint. The layers are commonly thin, that is, from a quarter of an inch to an inch. It forms a hill near Bamf. Saussure, § 1483, has described a black schistose quartz, which may be a siliceous schistus of the Germans.

The cellular, stalactitic, fibrous, and other structures, seem to occur only in small portions, and rather belong to lithology or gemmology.

MODE II. KERALITE, OR ROCK-FLINT.

Characters.

Texture, compact and uniform, but sometimes laminar.

Hardness, crystallic. Fracture, splintery, conchoidal: the scaly fracture distinguishes it from flint. Fragments, sharp.

Weight, granitose; sometimes, but rarely, carbonose.

Lustre, dull. Opake; but often translucent on the edges.

Colour, grey, black, green, &c.

It composes entire mountains.

Hornstein.

This rock is the *hornstein* of the Germans, Petrosilex. and the *petrosilex* of their writers in Latin; which has of course been confounded with the petrosilex of the Swedes and French, which is compact felspar. To avoid this confusion the Greek term keralite has been adopted, from Lametherie. Keralite is not fusible by the blow-pipe, but compact felspar generally is. It is also often found impregnated with metals, while compact felspar or felsite has perhaps never been observed to attend metals. Felsite also presents the various colours of felspar; while keralite chiefly passes from white, through grey, to black. It may be regarded as an impure quartz, and shares the sites and properties of that substance.

In England it is called chert, and often runs in veins or layers through lime-stone, particularly in Derbyshire.

STRUCTURE I. MASSIVE.

Aspect 1. *Common.* Bluish grey rock-flint, sometimes mamellated, and approaching to chalcedony, from the lead-mines of Bretagne. This is properly a vein-stone; and Brongniart has observed, i. 365, that such are *hornsteins*, though the appearance be waxy, as they are infusible. Felspar or felsite rarely appear as vein-stones.

Of a lighter grey, with blende and galena, from the same.

With different laminar shades of black, but not with a laminar fracture, from Giromagny in the Vosges mountains, France*.

Interspersed with native silver, from the famous mountain of Schlangenberg, or Zmeof, in the south of Siberia, which seems entirely to consist of rock-flint, mixed with silver.

From the great oriental chain of mountains in Siberia, where, according to Patrin, it underlays the *ribbon* jasper.

With crystals of felspar it forms what Werner styles hornstone porphyry, for which see the Siliceous Intrites.

Aspect 2. *Unctuous.* There is also an unctuous keralite, like what is called fat quartz. It is sometimes mistaken for felsite.

STRUCTURE II. LAMINAR.

Siliceous schistus.

Aspect 1. The *siliceous schistus* of Werner, a term very vague, as there are so many schisti of a siliceous nature, is by Mr. Kirwan and others regarded as a schistose hornstone. It is a primitive rock, usually of a greyish black, intersected with small veins of white quartz. Of this the basanite, or Lydian stone of Werner, is accounted only a diversity; but many regard it as a black jasper, and as all the jaspers are impregnated with iron, it would be truly surprising if there were no black jasper. According to Mr. Jameson, the flinty slate of Werner not only occurs in considerable beds in primitive slate, but also, like quartz, forms entire mountains.

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* In another work the author has said that, in the ancient phraseology, forests and mountains were often confounded. Roeslin *de Sylva Vasgovia* (that is, an account of the mountains of Wasgaw, or Vosges) is a modern example.

It appears by the French writers to have been sometimes confounded with a fine trap or basalt. Latterly siliceous schistus has been understood to present various colours; and when it occurs in grauwacke slate, is regarded as a transitive rock. The primitive is said to underlay the granite of Mount Sorel, in Leicestershire.

Chert.

Aspect 2. The *chert* of the English* chiefly occurs in layers in lime-stone, and sometimes constitutes a mass of petrified shells.

Dark grey chert, with lime-stone, in layers, from Derbyshire.

Reddish chert, with lime-stone, from France.

Brown chert, full of petrified shells, from Derbyshire.

In bowls, with concentric layers, brown and grey, from Vaucluse. Saussure, § 1546.

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* *Chertz* of some counties, which seems related to *quartz*.

MODE III. FELSPAR.

Characters.

Texture, strait, foliated.

Hardness, of course felsparic. Fracture, laminar. Cross fracture, fine-grained, uneven, approaching the splintery. Fragments, sharp, rather rhomboidal.

Weight, granitose.

External lustre, shining; of the cross fracture, glimmering, glassy, sometimes pearly. Translucent.

Colour, many varieties of white, grey, green, and red; rarely blue or black.

It often composes mountains, especially when interspersed with mica; and is the most abundant substance in granite, where it often forms distinct crystals *.

There are mountains and large strata of felspar in the north of Scotland.

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* It is sometimes classed with the Argillaceous, because some kinds decompose into clay; yet this effect probably arises from the potash. But it forms the chief part of granite, which has never been classed among argillaceous substances.

According to Lametherie, v. 9, felspar requires the most water to crystallise, so must be the most ancient; and is followed by hornblende, quartz, mica, magnesia, and the metals successively. But the grey petrosilex of Vosges is a felsite. Ib. 352.

STRUCTURE I. COMMON.

Aspect 1. Common foliated. This rarely forms entire mountains, but such have been discovered in Siberia. When it forms mountains it is generally white.

Aspect 2. Granular. Rocks of a fine white granular felspar, resembling statuary marble or dolomite. Sauss. § 2144.

Aspect 3. Unctuous. Saussure, § 1304, describes what he calls *felthspath gras*, or unctuous felspar, as having a visage more oily and translucent than common felspar: the fracture rarely laminar; and the plates, when perceivable, not being level, but often convex, so that almost all the fractures are generally conchoidal. It is harder, and less fusible, than the common.

STRUCTURE II. MINGLED.

This division may justly comprise numerous rocks and entire mountains, consisting of felspar interspersed with a little mica or quartz, or a few garnets; the preponderance of the felspar being so great that they cannot be considered as granitels.

Such rocks may be said to be always white, like those consisting of felspar alone.

Felspar rock, with a few garnets, from a mountain in the west of Scotland.

The same, lightly sprinkled with mica, from the Alps.

Petuntze.

The same, with a few grains of quartz, *Petuntze* of the Chinese, from Limoges, in France. The fine porcelain of Sevre is composed of this substance, the quartz being carefully separated. The same is also found in Cornwall, Saxony, China, and many other countries. When the felspar is decomposed into a white clay, it is called *kaolin*, and is also necessary in the fabrication of porcelain.

Kaolin.

Labrador.

Green of Siberia.

The beautiful opalised kind of felspar, called Labrador stone, is also a component part of rocks in Finland and Norway, where it only reflects the blue lustre; both kinds, when viewed alone, with the beautiful green felspar from Siberia, falsely called the Amazon's stone (which was found near the river of Amazons, in South America, and is a jad), rather belong to gemmology, as they do not constitute entire rocks. But the Labrador and Norwegian rocks, considered as a compound, are here classed in the Anomalous Domain.

MODE IV. FELSITE, OR COMPACT FELSPAR.

Characters.

Texture, compact.

Hardness, felsparic. Fracture, minutely foliated. Fragments, rather sharp, amorphous.

Weight, granitose.

Internal lustre, glimmering, or glistening. Translucent, sometimes only on the edges.

Colours, various, as of felspar, which may also distinguish it from keralite. Melts under the blow-pipe.

It is doubtful if it form entire mountains; but is an important rock, and among the most primitive.

Palaiopetre.

It is the *Palaiopetre* of Saussure, who found it near the summit of Mont Blanc; and a specimen which he sent to Lametherie, and which I have seen, is compact felspar, easily fusible by the blow-pipe.

Petrosilex of Wallerius.

It is the petrosilex of Wallerius, and in consequence of the Swedes and French; so that it must be carefully distinguished from real petrosilex, which literally implies the rock-flint of the Germans, being a modification of quartz, and not of felspar. The name felsite was very properly introduced by Mr. Kirwan; as a distinction between it and keralite seems first to have arisen from an accurate examination of the beautiful blue granite, discovered near Krieglach in Stiria, where it occupies the place of common felspar. The distinction, which is thus recent, forms an important step in the knowledge of rocks.

Wallerius sent a specimen of his petrosilex to France, which I saw in the possession of Haüy, being rose-coloured compact felspar, from Salberg. Saussure mentions a grey felsite, explored like slates near Martigny, in the valley of the Rhone; and the celebrated cascade of Pisse Vache falls from a rock of this kind[*]. His jad is also now called compact felspar. Patrin[†] saw in Siberia, near the celebrated silver-mine of Zmeof, a mountain with singular natural fortifications, composed of felsite. They rise about 200 feet above the body of the mountain; being on all sides as steep as a wall, and only pierced with a few difficult openings. The summit forms a platform, about 500 paces by 200, covered with blocks and fragments of various kinds of felsite, some laminar, others veined in zigzag. Some have the triangular form of half a cube, cut by its diagonal; and one large mass is composed of angular fragments of felsite, in a paste of the same substance, so as to constitute a brecia.

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[*] § 1046. Between Martigny and St. Maurice there is also a singular variety of rocks. Among them is a kind of petrosilex, grey, hard, and sonorous, with a little transparency, which rises in thin plates, perfectly flat and regular: hence it is used as a slate-quarry. It is probably of the same nature with patrinite, or laminar felsite. The rock of the famous cascade called Pisse Vache, seems of the same kind, but approaching nearer to a feljad, greenish, and semitransparent. It melts like a felsite, but with greater difficulty.

[†] i. 134.

When Dolomieu wrote, the knowledge of rocks was far from having attained even the present degree of precision; which is however so far from being perfect, that perhaps another enlightened century may elapse, before all the rocks shall have been discovered, analysed, and examined, so as to be reduced to their proper domains and modes. The following rock, with a base of his petrosilex, which is felsite, probably belongs to this division, though he mentions it after the toad-stones and variolites*.

Felsite of Corsica.

"I must here mention some glandular stones which I found in Corsica, chiefly in the valley of Nido †, and which have petrosilex for a base; none have appeared to me more curious nor more instructive. The very fine paste, which forms the ground of the mass, is of different colours, white, grey, red, or brown. The globules, whose growth may be traced from the instant when, having a diameter of half a line, they begin to be apparent, till they have acquired an inch in size, are generally black, with an aspect of horn, sometimes brown or red, but always of a different colour from the base: they are striated from the centre to the circumference, and have almost always a small crystal of felspar, or a grain of quartz, for a central point. Sometimes the gland is not completely formed; its place is only marked by the circular spot round the central grain. The greater part of these glands adhere strongly to their base, perfectly incorporating with it: some, but not those which are striated, may be detached, and leave their impressions. It seems to be a mixture of steatite which favours their separation. These globules, which are not always harder than the paste which contains them, are affected by fire like petrosilex, and only seem to differ from their base by the kind of texture that a peculiar aggregation has caused them to assume."

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* Journ. de Phys. 1794, p. 260, note.

† Niolo?

Dolomieu, following the observations of Saussure, § 1079, has demonstrated*, that the petrosilex of the Swedish and French authors is a compact felspar. It is sometimes of a greenish hue, from a small quantity of steatite dissolved in its paste; and sometimes grey or black, from a mixture of bitumen, as Dolomieu argues, from its becoming white before it melts. Felspar often passes into felsite, and the latter often contains little scales or crystals of the former.

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* Journal de Physique, new series, vol. i. p. 244.

Two kinds of felspar.

This ingenious, but prolix and discursive author, distinguishes two kinds of felspar; that which contains lime, and that which contains magnesia. The latter is more hard and weighty, and less fusible than the other; and as it approaches to the nature of jad, might, by a complex term, alike useful for precision and the memory, be called feljad. Some granites present both kinds, but felsite generally contains lime; it is also found with crystals of schorl, plates of siderite, or veins of quartz.

Feljad.

According to Dolomieu, felsite forms the base of several porphyries found in the valley of Niolo, in Corsica. One kind is green, and as fine as chalcedony, sprinkled with an infinite number of red dots, being little crystals of felspar. A brown felsite porphyry, of a schistose kind, is used for slates in the village of Pergine, in the bishopric of Trent.

"The mountains of Tyrol, between Trent and Bolsano, are almost entirely composed of porphyries, with a base of petrosilex of different tints; and the little valley of Fierrozo, in which flows the river Fersina, and at the entrance of which is the village of Pergine, might be called the valley of porphyries, from the infinite number of varieties which that rock there presents, always preserving the same base. There are grey, green, red, brown, black. There are some similar to bricias, of a green cement with pieces of other colours. The petrosilex in it gradually passes to the granitic texture, and to the state of schistose rock, without the beds changing their direction."*

STRUCTURE I. COMMON.

Rose-coloured felsite, from Salberg, in Sweden. This is interesting, as being the petrosilex of Wallerius, which led to many errors of the Swedish and French writers. He describes the following kinds†.

A scaly grey petrosilex, from Salberg.
A scaly brown, from Garpenberg.
The red scaly petrosilex, from Dalecarlia.
The green scaly petrosilex, from the same.
The blackish scaly, from Dannemora.

He then describes several specimens of a waxy fracture; and observes, that his petrosilex sometimes runs in layers in calcareous mountains; so that he has confounded the secondary hornstein with the primitive felsite. When a stone passes into jasper, it must properly belong to keralite or rock-flint, which, like jasper, is infusible.

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* Ib. 247, note.

† i. 280.

STRUCTURE II. LAMINAR.

This kind is observed by Saussure as already mentioned. It has been confounded by some with keralite or hornstein.

Klingstein.

The clink-stone of Werner, sometimes ridiculously called *basalte en tables* by the French mineralogists, may properly be classed under this division, as having no connexion with the basaltic modes, which are characterised by the abundance of iron, but most intimate relations with felspar, as will appear from the following analyses by Vauquelin and Klaproth:

	FELSPAR.		KLINGSTEIN.
Silex	62,83		57,25
Argil	17,02		23,50
Lime	3,00		2,75
Potash	13,00	Soda	8,10
Iron	1,00	(manganese 0,25)	3,25
Loss	3,15	(water 3)	4,9
	100		100

Klingstein porphyry.

The klingstein porphyry of Werner, which he also absurdly calls porphyry slate, is a schistose felsite, with crystals of felspar; as it happens in many substances that an earthy and compact base is spotted with crystals of the same substance, the forms of some of the molecules having disposed them to crystallise, while the others became sedimental. The klingstein porphyry is generally black or grey, but sometimes of a green, yellow, or brown tinge, like the klingstein, which seems to admit most of the colours of felsite; but is of a schistose texture, and contains little cavities, often lined with quartz crystals, much resembling lava with a basis of felsite.

Patrinite.

As the French seem first to have observed this rock, it may be called patrinite, in honour of Patrin, an eminent French Geologist and Volcanist. It sometimes contains zeolite, calcareous spar, and crystals of siderite. Mr. Jameson has observed that it is sometimes vesicular*, or full of little cavities, "but not so much so as basalt." Part of his description of patrinite may be transcribed.

Jameson's description.

"2. It occurs sometimes in tables and columns; also in veins that traverse sand-stone and greenstone, as in the island of Arran.

"3. It resists the action of the weather very obstinately. After very long exposure it becomes covered with a thin crust, which has usually a greyish-white colour, but a reddish crust in iron-shot varieties.

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* This epithet seems only applied to basalt, wacken, klingstein, lava, pumice.

"4. Like basalt it forms single conical hills; but they are not so regular, and are more marked with cliffs and irregular rocky forms.

"5. Excepting small traces of iron-pyrites, and iron-sand, it contains no ores.

"6. It appears from observations I have made in the islands of Arran and Lamlash, in Dumfries-shire, and on the porphyry-slate hills near Edinburgh and Haddington, that this rock passes, on the one hand, into compact felspar and clay-stone, and, on the other, into pitch-stone and basalt.

"7. It occurs abundantly in the islands of Arran and Lamlash, in the frith of Clyde; also in smaller quantities in the upper part of Dumfries-shire, and in the county of Selkirk. Braid hills, and part of the Pentland hills, near Edinburgh; the Girleton hills at Haddington, and, according to my pupil Dr. Ogilvy, North Berwick Law, and Traprain or Dumpender Law, in the same county, are composed of this rock. I suspect that the porphyry of Cumberland, which probably occurs among transition mountains, is also porphyry-slate. It occurs in great abundance in Bohemia; also, but in less quantity, in Lusatia; in the principality of Fulda; in the Rhongebirge; at Hohentinel and Hogau, in Upper Suabia; at Vicenza, in the Euganean mountains; on the Pic de Teyde, in Teneriffe; and in great abundance in South America, as I suspect that much of the porphyry of Humboldt will prove to be porphyry-slate."

It may likewise be observed, from Brochant's description, that patrinite sometimes occurs in globular masses, implanted in other rocks; and also sometimes assumes the prismatical form, in groups of more or less regularity.

To these remarks may be added the curious description by Klaproth, which accompanies his analysis.

Klaproth's account.

"The schistose-porphyry is a species of stone, which, notwithstanding that it so frequently occurs, and even in masses forming entire mountains and rocks, yet was doomed by a singular fate long to continue to be disregarded, unknown, and confounded with other stones.

"The first denomination, under which it has been admitted in oryctognostic treatises, is that of *hornschiefer* (horn-slate). However, this name does not exclusively belong to it; for which reason various authors denote by the same name several different species of stones. This German denomination seems to have been occasioned by the Latin *corneus fissilis* of *Wallerius*; though it is obvious from the description which he has given of his *corneus fissilis*, that he did not mean to signify by that name our schistose-porphyry, which, as it seems, he did not know, but the *hornblend-schiefer* (hornblende-slate of Kirwan).

"Other authors, as Born, Ferber, receive under this name, sometimes different varieties of the *thonschiefer* (argillaceous slate), and sometimes *glimmerschiefer* (micaceous slate).

"The first oryctologist who has awakened the attention of naturalists to the schistose-porphyry, and given of it an accurate description, was Charpentier, in his Mineralogical Geography of the Electoral Dominions of Saxony. At the same time he gave to it exclusively the name of horn-slate, in which he was followed by most of the German mineralogists. But Werner thought otherwise. He left this name at first to that species of stone, which afterwards has been called kieselchiefer (siliceous slate); and denominated that which is the subject of the present essay *schistose-porphyry*, in order to distinguish it as a peculiar species of porphyry. In fact, it exhibits the mineralogical character of porphyry: as it principally consists of an homogeneous, hard, siliceous and argillaceous aggregate, in which, though but sparingly, and singly, are interspersed small lamellæ of feldspar, besides minute grains of hornblende; yet at the same time it is distinguished from the common species of porphyry, by its gross slaty fracture. But since to the principal mass of this stone the name of *klingstein* (soundingstone) has been given, because its larger plates, when struck, give a sound almost metallic; it seems that the name of *klingstein porphyr* (klingstone porphyry) would be more characteristic, and more conformable to analogy.

"From this short historical account it may sufficiently be seen, what great uncertainty and want of accuracy has even of late prevailed in the geological knowledge of the mountainous part of the globe. For this reason the editor of the magazine for the Natural History of Swisserland has highly merited the thanks of the public, for having occasioned, by means of a prize question, that this intricate subject has been investigated by two learned mineralogists, Karsten and Voigt, and correctly explained in their two papers, crowned with the prize: "On argillaceous schistus, horn-slate, and on wake*."

"The klingstone-porphyry belongs to that division of mountains which, by modern geologists, are classed with the trap-mountains*. In Germany it occurs chiefly in the middle mountains of Bohemia, in Upper Lusatia, and in the district of Fulda. It does not form coherent ranges of mountains, but always only detached masses of rocks and insulated mountains, commonly on the side of similar basaltic mountains. It belongs to the most durable *saxa*, and resists the withering in an eminent degree. Only on its surface some decay takes place, by which it acquires a pale clayey crust, the smoothness of which renders the ascension on klingstone-porphyry mountains somewhat unsafe. Some of these mountains, though but sparingly covered with fertile soil, are nevertheless well invested with plants and forest-trees; as for instance the Donnersberg, near Milleschau, and the Schlossberg, near Töplitz. But most frequently the klingstone-porphyry occurs in the shape of cliffs, which are dentated in a grotesque manner, from the unequal, mostly vertical, separations into large plates and ill-formed pillars. Examples of such grotesque rocks, are the Bilinerstein, near Belin, and the Engelhaus-berg, not far from Carlsbad.

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* "Magazin für die Naturkunde Helvetiens," by Dr. Höpfner. Zürich, 1788. Vol. iii. page 168, seq.

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* In the German *trapp formation*. This expression is now, according to Emmerling, by the latest German mineralogists used to signify all mountains constituted of grünstein, amygdaloid, schistose-porphyry, basaltes, and their subordinate species. All these are called *trapp-gebirge*, since those *saxa* not only occur in mountains of the same kind, but also very much agree in their geognostic relations; so that evidently they are of the same formation. Transl.

"To complete the history of this stone, I must briefly notice an opinion which has of late been in vogue, and even now seems to have its abettors. I mean, that the klingstone-porphyry, as well as the basalt, the amygdaloid (mandelstein), and other trap mountains, have been considered as volcanic productions, or lavas. It does not belong to the object of the present inquiry to repeat and to examine what on both sides of the question has been argued, and sometimes with violence disputed. I shall only mention, that in the several attentive inspections with which I examined, in the middle mountains of Bohemia, the sites of basalt and klingstone-porphyry, I could not discover the least vestige of a crater, or other signs of a volcanic nature; no more than any other unprejudiced observer would have been able to find.

"To these short geognostic remarks I shall now add the description of the external characters of the mass, which chiefly constitutes the klingstone-porphyry.

"The colour of the klingstone is grey, now and then a little inclining to the green. It occurs only massive. It has a fine grain, an uneven, coarse-splintery, fracture, and bursts into thick slaty fragments. The edges of its thin splintery fragments are transparent. It is pretty hard, and at the same time considerably tenacious. When triturated, it yields a light grey powder.

“ Its specific gravity is 2,575.

“ The lamellæ of a greyish white, strongly splendent felspar, which are interspersed in its substance, together with the very minute crystals of a black hornblende, give to it the character of porphyry.”*

The result of the analysis is—

“ Silex	57,25
Alumine	23,50
Lime	2,75
Oxyd of iron	3,25
Oxyd of manganese	0,25
Soda	8,10
Water	3
	98,10

“ The reflecting natural philosopher will know, without my suggesting it, how to appreciate the value of this discovery of the presence of soda, as a constituent part, in a stone which occurs in masses of the size of entire mountains. It opens to him a new view, and leads him a long step farther in his geological inquiries. We now see that there is no longer any occasion for the theory hitherto prevailing, according to which it was imagined necessary to consider all the soda, which in nature occurs either in a free, that is uncombined, or in the carbonated state, as an educt arising from a decomposition of rock salt, or of sea salt, or of that from saline springs, supposed to have been carried on by nature, and to have taken place in an unknown manner.

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* Klaproth Anal. Essays, ii. 182.

"The klingstone employed in the preceding experiments was from the Donnersberg, near Milleschau, the highest of the middle mountains in Bohemia. The whole mass of this majestic cone, which is above two thousand five hundred feet high, consists entirely of this stone. From its summit the picturesque fields of Bohemia, extending for many miles around, present themselves to the eye, collected as it were in a pleasing miniature painting; while at the same time, at a farther distance on the eastern horizon, the Bohemian and Silesian Giant-mountains, and on the west the Franconian Fichtelgebirge (mountainous region), are discovered.

"If we now reflect, that in this enormous mass of rock, the soda constitutes nearly the twelfth part of the whole, I hope it will not be thought an exaggeration to say, that this mountain alone is capable of providing, for a long succession of years to come, all Europe with sufficient soda; presupposing, however, that expedients should be devised to separate this alkali from the stone by a cheap and profitable method*."

STRUCTURE III. EARTHY.

This is described by Saussure as of an earthy or granular appearance, with long and irregular crystals of black siderite, sometimes greenish. The rock was mistaken for a sand-stone. He also mentions, § 1136, a rock of a violet red, which he conceives to consist of the earth of felspar not crystallised.

Earthy klingstein-porphyry, from Mont Dor, described by Daubuisson in his account of the basalts of Auvergne.

The following varieties may also be added from the former great petralogist:

Rocks of felsite, with veins which at first might be taken for granite, but upon examination is found to present only felspar and mica, and sometimes only felspar confusedly crystallised. Sauss. § 1194.

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* Ib. 182.

A rock of green and violet layers, being a kind of felsite. Sauss. § 1448.

What he calls a trap, with a paste of a greenish grey felsite, and grains of quartz and felspar. § 2043.

Rotten-stone. § 1558. The rotten-stone of England may be regarded as a kind of tripoli, but is neither porous nor of a slaty structure. He concludes that tripoli consists of a fine sand of felsite.

MODE V. GRANITE.

Composition. This important substance, which composes the highest chains of mountains, and was used by the Egyptians in the earliest monuments of art, is chiefly composed of felspar and quartz, which have been already described: a third substance is also indispensable in granite, namely, either mica or siderite. And even when both these latter are joined, the most exact mineralogist or geologist could not refuse the strict appellation of granite, as different mixtures may be found in no very remote parts of the same rock. As some granites, instead of felspar, present felsite, yet are universally admitted into this class; so the mica may pass into talc or steatite, or siderite, as on the summit of Mont Blanc, and the siderite into iron, without changing denominations. Crystals of schorl, or garnets, not to mention the precious stones, may also appear in genuine granite; but the real and severe denomination can in no case be further extended. When there are only two essential substances, with a granitic appearance, as particularly quartz and felspar, the term granitel must be admitted, with Saussure, Kirwan, and other celebrated geologists; though in Italy *granitello* is used by artisans for a complete granite, composed of very small grains, here called *granitin*; as basaltin is a fine basalt, and porphyrin a fine porphyry.

Granitel.

These observations become the more necessary, as no substance has engaged more attention in systems of geology, and no two authors seem hitherto to be agreed in precise and formal definitions of granitic substances: and in all sciences it is well known that no question can be settled, or even accurately discussed, without the most precise definitions. Thus in the question concerning the entrance of granitic veins into primitive schisti, some deny that the granite in these veins is of the same mixture with the mass; and it certainly would considerably influence the discussion, if the mass be a complete granite, and the veins only granitel. Nor in fact can there be any just science, if terms be used in a lax acceptation; and it is far better to err in the contrary extreme, which can only be accomplished by increasing the number of distinctions and denominations, as has been done in gemmology.

Granite, with siderite.

As siderite has been shown to be among the most primeval substances, and is found enclosed in the crystallisation of the most ancient granites, so as to evince a priority of formation to the quartz, or the felspar, which never appear to be intercepted by the siderite; so it may be assumed that a granite, consisting of felspar, quartz, and siderite, with or without the addition of mica, may be regarded as among the most ancient, if not absolutely primary. Saussure observes that there is no mica in the granite on the summit of Mont Blanc, its place being supplied by siderite; and remarking the same difference to occur in the granite ejected from the depths of the Italian volcanoes, he is led to the reasonable conclusion, that this construction, being found at the greatest heights and the greatest depths, must be the most primordial. It is also remarkable, that as the nucleus of the earth is inferred by astronomers and natural philosophers to consist of iron, which is seldom found free from silex, so a great part of the summit of Mont Blanc consists of granitel*, or a mixture of felspar and siderite; and the base of all lavas consists of one of these two substances. Whether however we join the Huttonians, in considering granite as the newest substance, the last ejected from the bowels of the earth; or the Wernerians, in regarding it as the most ancient, being deposited from above, we must be allowed to view a substance composed of felspar, quartz, and siderite, as not only a complete and genuine granite, but as perhaps the most noble denomination of that class.

As Mont Blanc is the most remarkable granitic mountain in the world, it may be instructive to translate Saussure's curious and interesting account of its summit. Of the rocks which that great observer discovered near the summit of that mountain, he gives the following description; which shall be followed by that of the rocks observed on the summit itself†.

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* This, as Saussure especially mentions, § 1994, was the syenite of Werner at the time when he wrote, A. D. 1795; but Karsten about the same period defined the syenite of Werner to consist of quartz, siderite, and felspar. Jameson however regards syenite as composed of felspar and hornblende; but Kirwan agrees with Karsten. Daubuisson, who is commonly exact, says that syenite is composed of felspar and siderite; and that any quartz or mica is accidental.

† Saussure, § 1999, supposes that the summit of Mont Blanc was originally about two leagues under the surface of the earth.

1987. "The naked rocks that we there meet with, and which form two kinds of *arretes* or crests, of a black colour, and somewhat saliant, which we clearly see from the banks of our lake to the left of the highest summit of Mont Blanc, are granites, here detached in scattered fragments; there, in solid rocks, divided by fissures nearly vertical, whose direction is conformable to that which generally predominates in these mountains, that is, from the north-east to the south-west, and which I consequently regard as layers.

Summit of Mont Blanc.

"The felspar which enters into the composition of these rocks is white approaching to grey, or green, or redish; it yields under the blow-pipe a glass, from which we may obtain globules of 0,6, transparent, colourless, but full of bubbles.

"The felspar is here pure, there covered or even mixed with a substance of a grey, inclining to a sea-green, colour; without lustre, earthy, soft; when scratched, whitish grey. This substance appears to be an earthy steatite; it is difficult to obtain pieces of it free from felspar; those that I separated, melted under the blowpipe into a greenish glass, translucent, and of a very unctuous aspect. They became discoloured on the iron rod, and dissolved with effervescence.

"The whitish, semi-transparent quartz, which enters into the composition of this granite, appears a little unctuous in its fracture; a fragment, of the fifteenth of a line long by a thirtieth in thickness, or of 0,067 by 0,033, fixed at the extremity of a thin rod of iron, became perfectly rounded in the flame of the blow-pipe, losing a little of its transparency, which in this piece appeared perfect, and some bubbles rose in *its* interior. This quartz is therefore more fusible than rock crystal, in the proportion of 0,035 to 0,014.

" These granites are frequently mingled with hornblende, here blackish, there inclining to green.

" There is also seen chlorite, often of a blackish green, sometimes in veins, sometimes in nests, and even in pretty thick masses. It is soft, but not friable; of a very fine grain, and its small particles, viewed by the microscope, appear very translucent thin plates, of a bright green; but they have not the regularity of those of St. Gothard, which I have described in § 1893. This fossil, like hornblende, appears to retain in these granites the place of mica, which does not appear in it, except in very small and scarce spangles.

" Some of these granites appear curious, there being small cavities of angular and irregular forms, full of a rust, or brown dust. In breaking these granites, we find in their interior small pyrites, brown and dull on the outside, but brilliant and of a very pale yellow within, and whose fragments are attracted by the magnet. It is from the decomposition of these pyrites, that the cavities arise. My guides found fragments of these granites, wherein were cubical pyrites from three to four lines in thickness, whose fracture is very brilliant, and of a very lively brassy yellow: these do not decompose in the air.

"We also find in these rocks quartz, with veins and nests of delphinite, or green schorl of Dauphiny (actinote); it is but confusedly crystallised, but easily known by its puffing up under the blow-pipe, and by the black and refractory scoria into which it is changed.

"In some parts these granites degenerate into irregularly schistose rocks, composed of quartz and felspar, without any mixture of mica, and whose layers are separated and covered with an argillaceous, nut-brown, ferruginous earth, which melts into a black glass.

"These same rocks of granite contain a vein of granitel almost entirely composed of laminar black and brilliant hornblende, and of grey translucent felspar, which assumes outwardly a rusty colour.

"In short, my guides found also in these same rocks a *palaïopetre,* or primitive petrosilex, of a grey approaching a little to green, translucent at the thickness of a line, and even to 1, 2, scaly in its fracture, hard, interspersed internally with dots of a deep green, which are scarcely visible but with a magnifying glass, and which appear to be steatite; and also some rare dots of pyrites, which, in decomposing, stain of a rusty colour the vicinity of the places they occupy. This stone melts under the blow-pipe into a white and bubbly glass, like that of the felspar."

Our intelligent author thus describes the rocks he observed on the summit itself of this celebrated mountain:

1990. "These rocks, situated nearly 2400 fathoms above the sea, are interesting by their being the most elevated of our globe that have been observed by naturalists. M. Bouguer and de la Condamine ascended the Andes of Quito to an equal height, and even some fathoms higher than that of these rocks (2470 fathoms): they were not however acquainted with rocks; but as they are said to have sent to France chests full of specimens of the mountains, on which their trigonometric operations had conducted them, I could have much wished that these specimens were examined by connoisseurs. The late duke of Rochefoucault, a man equally distinguished by his knowledge as by his virtues, and who fell the innocent victim of the troubles of a country for which he had made, and would have yet made, the greatest sacrifices, was very willing, at my entreaty, to make the most careful researches after these specimens, either at the King's garden, or at the Academy of Sciences, of which he was a member; but he was neither able to discover them, nor any trace of what had become of them.

"The scarcity of specimens of rocks situated in similar heights, and the inferences we might draw from their nature in different systems of geology, induces me to give a detailed description of these.

"They are like those of § 1987, granites in mass, where hornblende and steatite hold the place of mica, which is there extremely thinly scattered; the sun and a magnifying glass are necessary to enable us to perceive some white and brilliant spangles; it is even doubtful if these brilliant particles, which it is impossible to detach, are really mica.

"Felspar forms the dominant part of these granites; constituting about three fourths of their mass. Their crystals, nearly parallelopipeds, vary as to size; there are some which are an inch long, by six lines broad. They are of a dull white, slightly translucent, little brilliant, of the kind I have called dry; under the blowpipe they yield a transparent glass, but with bubbles, from which may be formed globules of 0,81, and consequently fusible at the 70th degree of Wedgewood. Upon the rod of sappare the bubbles dissipate, and there remains a transparent milky glass, which sinks without penetrating or dissolving. These crystals of felspar appear here and there greenish and dull, on account of a slight coat of earthy steatite which covers them.

"The quartz, which forms a little less than the fourth of the mass, is of a grey approaching to violet colour; its fracture is uneven, brilliant in some places, not scaly, but here and there rather conchoidal, a little flat. Its fusibility is nearly the same as that of the quartz of the granites of § 1987.

"The hornblende, which forms in the mass too small a portion to be estimated, is of a black approaching to green; it shows some tendency to the laminar and brilliant form; but it is more often merely glimmering, and almost earthy; fusible into a brilliant black glass, but porous in its interior; and which on the rod of sappare passes to the bottle green, through the brown; afterwards loses its colour, and dissolves with some effervescence, which proves there is a mixture of magnesian earth.

"The earthy steatite, which also forms a very inconsiderable part of the mass of these granites, resembles that of § 1987.

"All these granites have their natural divisions covered with some coat, either green or blackish. This is an earth like chlorite, of a green almost black, and a little shining on its external surface, but of a more bright green and earthy in its fracture; soft, scratching with a greenish grey streak; at first turning brown under the blow-pipe, then yielding a knob = 0,3, or fusible at the 189th degree of Wedgewood. This knob has a metallic aspect, somewhat unequal, and a little dull, like that of bars of melted iron; and not only the knob, but all the parts that the action of the flame renders brown, are strongly attractable by the magnet. A small fragment tried upon the rod of sappare, at first infiltrates like ink between its fibres, then becomes of a dull brown, and at length entirely discolours, but without any appearance of dissolution.

"The green coat which covers other pieces of these granites in their spontaneous divisions, is less dark, pretty shining, translucent, smooth and even a little unctuous to the touch, soft, easily scratched to grey, changing under the blow-pipe into a translucent glass, which becomes transparent on the rod of sappare and dissolves, but without effervescence. This coat appears to be of the nature of steatite; but I have not been able to obtain pieces of it sufficiently large to measure its degree of fusibility."

The rocks of the southern parts of this summit he thus describes, § 1993:

" 1. Granites perfectly similar to those before mentioned, § 1987.

" 2. Syenites or granitels, that is, rocks composed of laminæ of black hornblende and white felspar, also laminar, but both in such small parts, that we may as well give the name of *trap* to these rocks, according to the definition I have given in § 1945.

" 3. A primitive petrosilex, or *palaïopetre*, of a pearl grey, translucent to two thirds of a line, with a scaly fracture in large and small scales, sufficiently hard to yield bright sparks, but having a grey streak when scratched by a sharp-pointed steel. Under the blow-pipe we may form globules of 0,45; which indicates the fusibility of pig-iron, 126 or 130 of Wedgewood. It is a grey glass, semi-transparent, bubbly, which on the rod of sappare gains in transparence and sinks, but without penetrating or dissolving, and even without entirely losing its bubbles.

"This palaïopetre contains veins of from one to three lines in breadth, which cross at different angles, and small nests of a deep leek-green hornblende, confusedly crystallised, or in plates rarely straight, or in middling large fibres."

STRUCTURE I. OF A LARGE GRAIN.

Aspect 1. Felspar, quartz, and siderite, often joined with mica.

Red granite of Egypt, from the quarries visited by many travellers beyond Syene, whence it is called *Syenites*, by Pliny, who specially mentions that the obelisks are composed of it; while it is universally admitted that they are a mere and genuine granite, often containing no siderite *.

Syenites.

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* Both Agricola and Aldrovandi mention syenite: the latter says, *Vulgus appellat hoc genus marmoris* granitum rubrum *cum antea diceretur* pyrrhopoikilon; the latter word being also used by Pliny to denote the fiery red variegation of the felspar.

The celebrated Zoega also informs us positively that all the obelisks are of the ancient Syenite, that is, as he adds, our red granite. "Verum enimvero omnes obelisci in Europæ civitatibus obvii, ubi excipias unum Florentinum (*e granite fusco*), et maxima quoque pars eorum qui in Ægypto exstant, atque in Abyssinia; facti

The learned M. de Sacy, in his recent translation of Abd-allatif, or Abdolatiph*, who, about A. D. 1210, wrote a curious account of Egypt, uses the words *elle est de granit, de cette pierre rouge, tiquetée, qui est d'une extreme dureté.*

It appears from the same work that some of the pyramids were covered with granite, and even with hieroglyphics; which the Arabian author says might fill a book of ten thousand pages. Grobert, in his description of the pyramids, mentions the fragments of that covering, as granite of rose-coloured felspar, a little quartz, and black siderite, like that of Elephantina, near Syene. This covering existed till at least the thirteenth century. Curious authorities concerning the granitic column called Pompey's, particularly that of Apthonius,

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bente *Syenite* lapide, quem et *pyrrhopœcilum* vocat Plinius; Itali autem *granito rosso*, lithologi *granitem rubrum*." Zoega de Obeliscis Romæ 1797, folio, p. 140.

. Petrini, on breaking some pieces, found that when there was hornblende, it was always mixed with mica; as it is in the large black spots. Ibid.

Granite seems first to be mentioned by a writer of the middle ages, Vacca, whose description of Rome is published by Montfaucon in his *Diarium Italicum*. Vacca repeatedly mentions *marmor granitum Æthaliæ insulæ*, that is, "granite marble from the isle of Elba," whence he supposed it came. The word *granito* is probably as ancient as the restoration of the arts in Italy, in the thirteenth century.

* Paris, 1810, 4to. p. 182.

A. D. 400, may be found in the same work. It belonged to the *Serapeum*, which was a noble library, much reduced by Diocletian, when he ordered the Egyptian works of alchemy to the flames[*].

The same, with large patches of siderite, in the sphinxes of the museum at Paris.

The same, running in veins through grey granite.

Grey granite of Egypt, consisting of felspar, quartz, and siderite: the *psaronion* of the ancients, from its resembling the colours of a starling.

Black and white granite, consisting chiefly of siderite with quartz, and a little felspar.

Dull green granite, of green siderite, with a little quartz and felspar.

Yellowish granite, of granular quartz, yellowish felspar, and greenish siderite, in large plates with metallic lustre, from Zillerthal.

Red granite, of felspar, quartz, and hornblende, from Peterhoff in Russia.

The same, from Mount Sorel in Leicestershire.

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[*] Oros. vi. 15. Some theoretic French writers had inferred that the Egyptians were negroes (in opposition to the mummies themselves), because they thought the Sphinx has negro features. Abdallatif, p. 179, tells us it was originally painted *red*, and the colour was still fresh in his time; nay Grobert, p. 32, observed a yellowish tinge in parts not rubbed.

It also appears in masses on the road to Quamdon.

It is also found in Greece, Norway, Saxony, the Hartz, Suabia, Stiria, Scotland, and many other countries.

Aspect 2. Felspar, quartz, and mica. Red granite of Egypt, without siderite, which, as Wad justly observes, constituting all the obelisks, is the real *Syenites* of Pliny. The mica is sometimes greenish black, sometimes tombac brown, sometimes grey, sometimes black.

The same, variegated with grey felspar.

Grey granite, *psaronion*, of the same composition, from the same country.

Green granite. Of this I have only seen one specimen, found by Roziere in the ruins of Ombos, in Upper Egypt. It is the most beautiful of all the granites, the felspar being of the finest emerald green, the mica silvery, and the quartz transparent white*.

Blue granite, of white quartz, silvery mica, and felsite of a sky blue, from Krieglach, in Stiria. This granite, which is found in large masses in the highway, only yields in beauty to the green of

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* Besson, in his memoir on the granitel of Corsica (*J. de Ph.*), mentions a granite of greyish quartz, and beautiful semi-transparent green felspar.

Egypt. Born says, that even the quartz is sometimes tinged with blue; which may be the Prussiat of iron.

Red granite, with large mica, approaching to talc, from Portsoy, Scotland.

The same, with crystals of schorl, from the same place.

Red granite, joined with Tirey marble, from the Isle of Tirey.

Rose-coloured granite, from the Lago Maggiore.

Brown, or Isabella colour, from the Vosges mountains, France.

For the green of the Vosges, see Talcous rocks.

White granite, from the Alps, which are chiefly composed of this substance.

Reddish granite, from the Carpathian mountains. Born, i. 377.

Red granite, in which the felspar assumes a round or oval form. This granite, found not far from Petersburg, forms the basis of the statue of Peter the Great. Patrin, i. 95*.

Pale yellow granite, from Greenland.

Granite, with pearl-coloured felspar, from Austria.

Granite, with red felspar, and very long-grained mica, which passes into siderite, from the celebrated quarry near Petersburg. Karsten Lesk. Mus. 374.

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* Pini (Felspaths de Baveno, 1779, 8vo. p. 41) mentions oval crystals of felspar, like a cylinder on an oval base.

Granite, with milk-white felspar, spotted with red, from the same place. Ib.

Granite, with tombac brown mica, from Bohemia.

Granite, with Labrador felspar, from Norway.

White granite, of which the Escurial was built, from Spain.

Violet granite, containing large crystals of violet-coloured felspar, from the Isle of Elba.

Grey granite, from the Hartz.

White granite, from the Cevennes mountains.

Dark blue granite, from Brazil.

Black granite, with black felspar, from the Alps.

Grey granite, from Cornwall, the *moorstone* of the country. It is white, with black and white mica, large-grained, and takes a good polish. Da Costa, whose book appeared 1757, says, p. 273, that it abounds with that *kind of quartz* which is called *felspar* by the Germans. In the infancy of the science the names of discrimination were very few; and they will increase in proportion as it advances*.

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* In his *Observations Mineralogiques sur les Vosges*, Nancy, 1782, 8vo. Sivry informs us, p. 93, that, on a mountain near Giromagny, there occur varieties of beautiful granites in detached blocks;

The granites near the Hermitage, in Dauphiny, which yields the famous wine so called, often present specks of a greenish black mica in the very heart of the crystals of quartz; being palpably the same mica which is interspersed through the granite. Sauss. § 1621.

A granite, which Saussure says is of a new formation, crystallised in the crevices of mica slate, mostly composed of felspar, partly also with quartz and mica. § 1267.

A granite, of which the quartz is of a lavender blue, the felspar of a yellowish white, and the mica, which is rare, of a dull leaden colour. § 2144.

Granites with round crystals of felspar, like that of Finland. § 1195.

STRUCTURE II. OF A SMALL GRAIN.

White granite, with black siderite, from Mount Sinai. On this, according to tradition, the Laws of Moses were engraved.

Red granite of Egypt, passing in a vein through grey granite, with patches of siderite, brought by Roziere from the quarries of Syene.

which, from the sharpness of their angles, and other symptoms, seem even to have crystallised apart. These are, rose-colour with green spots, black with white spots, green and white, grey with red spots, brown with green veins.

Grey granite, of quartz felspar and siderite, from Egypt. Wad.

Small or middling grained granite, with felspar partly grey partly red, from Egypt. Wad.

Grey granite, from the same country, veined with felspar partly grey partly red. Id.

Most of the kinds enumerated in the former Structure may also be found in this. For the smallest or very minute grained, see granitin.

Small grained white granite, with siderite, from the summit of Mont Blanc.

White quartz, brown or reddish felspar, and black siderite, from the Italian Alps.

The same, from the Isle of Elba.

Grey granite, with garnets, from Bohemia.

The same, from Norway and Scotland.

Grey granite, from Alençon. This is the common granite used at Paris.

Grey granite, with nodules of granitin, from the Alps of Dauphiny.

Light grey granite, with red lines composed of garnets, from Namiest in Moravia.

Grey granite, with veins of basaltin, from Norway.

Secondary granite, in thin layers, from the cave of Gribon, Isle of Mull.

STRUCTURE III. VEINED.

Saussure has described this rock with such accuracy and precision, and has himself so distinguished it from gneiss, that it is surprising it should since have been referred to the latter. In gneiss the veins of mica run parallel through the rock, which regularly splits in their direction. In veined granite the seams of mica are irregular, and terminate abruptly in various directions, being met by the solid rock.

Saussure discusses, § 1726, the differences between gneiss and his veined granite. In the latter the elements are interlaced among each other; while in gneiss there are fine leaves of pure mica, which alternate with leaves composed of quartz and felspar.

He mentions, § 1799, an extent of more than four leagues and a half of veined granite in horizontal beds: and, § 1802, veined granite in double zigzag, sometimes between other beds in right lines, which proves, according to Saussure, that it is the effect of crystallisation. That veined in zigzag is of a very fine kind, the quartz being scarcely distinguishable, while the beautiful white veins appear to be entirely composed of granular felspar, resembling a small-grained marble. The mica is also in small spangles, some black, but chiefly of a beautiful silver white.

STRUCTURE IV. MINGLED.

Some of this kind have already been incidentally mentioned. Besides schorl and garnets, Saussure observed chalcedony in granite, for which see the Composite Rocks. Chlorite and actinote are not uncommon in granite; and the talc sometimes passes into steatite. Even calcareous spar has been found in granite; and, when decomposed, porcelain earth, for which see the Decomposed Rocks. Not to mention the metals; primitive gypsum, anthracite, gneiss, basalt, and other substances, also occur in granite.

Granite, in veins in schistus, Saussure, § 599, from Valorsine. He describes it as passing through his roche de corne, which is generally a magnesian basalt; the granite is of grey quartz, white felspar, and grey mica, and is regarded by him as formed by infiltration.

Granite, in veins in primitive slate, from Scotland.

Granite, with veins of granular quartz, from Forez, France.

This account of one of the most important and interesting rocks, shall be terminated by Zoega's ideas concerning the manner in which it was sculptured by the ancients, as they may perhaps afford useful hints to the modern artist*.

Ancient sculpture.

"Some further observations occur concerning the Barberini obelisk, in the engraving of which some instruments seem to have been used, of which there is no vestige in the large obelisks; for the straight lines, or those which form segments of circles, are neither sharply cut, nor have they an equal depth; but the concave bottom is deeper in the middle part, and fainter at each end, till the lines gradually vanish. Nor do they terminate precisely in the point assumed by the sculptor; but the slender portion extends beyond the limits of the figure.

"Hence it is clear that the furrows were not made with a graver, nor with emery, rubbed as usual with a blade in the form of a knife, but with a kind of semicircular saw, to which emery was subjected, and by alternate motions of that instrument. But in the right lines only; for where they are curved the saw must also have been of that shape. When however the figures, which rise in the cavities, are more turgid, and each part disfigured with some globosity, it is probable that they were formed with a little auger or trepan, or a kind of tube or hollow borer, by the assistance of emery, although no vestige of such an instrument appear, the surface of the figures having been polished by friction. It was natural that the artists should study to save time in this kind of work, and effect by saws, *tuctri*, and friction, what appears to have been accomplished in the great obelisk by the chisel or graving tool, or emery rubbed with a blade.

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* For the original, see Appendix.

"6. Our artists, when they wish to cut any figure on granite, in the first place make a model of a thin plate of iron, which being fastened to the plane stone, they take another plate like a short knife, and use it to cut a furrow, by the help of emery, around the model first mentioned. The furrow being thus impressed to a certain depth, they take off the model, and begin to attack the intermediate space with a sharp graver or chisel called *subbia*. They then begin to form the figure, with a little sharp hammer called *pungetto;* and afterwards soften it with a broader hammer called *martellino*. This done, they polish it with lead and emery; and afterwards add the smaller lineaments, partly with a fine chisel, partly with the blade in the form of a knife and emery. Lastly, they polish the whole with the finest emery, called *spoltriglia*.

"7. Del Rosso thought he discovered marks of the auger in the obelisk of Heliopolis; and affirms, that without this instrument characters could not be cut in a granitic rock. But he seems to discuss a subject which he had not studied; for there could be no use for the common auger, also called a trepan, in this stone, which is harder than iron. But the other auger, which is a brass tube contrived to act on emery, though a convenient instrument, is yet unnecessary, and is only used by our artists in forming deep furrows."*

MODE VI. GRANITIN.

Description.

When granite is composed of extremely minute particles, it is not easily distinguished from basalt, or rather from basalton, the grunstein of Werner. But where particles of siderite, or even of basalt, which is an earthy siderite, are mingled with particles both of quartz and felspar, the substance is a granitin. When siderite is mixed with felspar alone, it is basalton, or the green-stone of Werner; the real basalt, or ironstone of the ancients, seeming properly to admit of no mixture, except spangles of siderite.

Several ancient monuments, supposed to be green basalt, are really of granitin with particles of siderite, as mica is never so much comminuted. Granitin also often forms nodules, or veins, in large or small grained granite, in almost every country where that substance occurs; but this substance being rather of microscopic observation, the specimens are not common. Green basalt. Green basalt, properly so called, should be homogeneous, or present only spangles of siderite; but may contain occasionally very minute particles of quartz only. The Isis of the Capitol, Ferber, 231, is of granitin.

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* Zoega de Obeliscis, p. 189, seq.

MODE VII. GRANITON.

When the crystals, especially those of felspar, are extremely large, that is, from two to six inches or more in length, the substance may well be called a graniton. It is common in the Alps, and other granitic mountains; and examples may be seen in the foot pavement of Westminster bridge*. Graniton presents the common colours of granite, that is, white, grey, and red.

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[*] Mr. Smeaton says it came from Llanlivery, near Fowey, in Cornwall.

Graniton may also be denominated, from the mica assuming the size of plates of talc.

Other aggregates, often confounded with granites, may be found in the division of Composite Rocks.

MODE VIII. GRANITEL.

Definitions.

The mountains called primitive chiefly consist of four substances, blended in various mixtures, namely, felspar, quartz, siderite, and mica. Without three of these substances the appellations of granite become vague and improper; and have occasioned great confusion in orology, or the description of mountains. Where only two occur, the greatest of all geologists, Saussure, has used the name *granitel;* and his appellations, when not contradicted by necessary distinctions arising from recent discovery, ought always to be received with singular respect. The term granitel is also confirmed and appropriated by the circumstance, that as the word granite is now consecrated by universal and perpetual usage, being derived from the Italian *granito*, as presenting the appearance of grains or kernels *; so a modification of granite ought, in due analogy, to receive its name from the same language.

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* It has been ridiculously said, that it is derived from the *geranites* of Pliny; which would only imply a stone shaped like a

Granitel sometimes consists of as minute particles as granitin, so as to assume the appearance of a coarse basalt. From this confusion, as Wad observes, some of the Italians denote the same substance *granitello verde di Egitto*, which others call *basalte verde*. He describes two specimens*: "1. Granite with very minute grains, consisting of greyish white felspar, and siderite of a dark green, in equal portions. 2. Granite of a very small grain, composed of greyish white felspar, and greyish black siderite, mixed with a larger portion of olive-green siderite, which renders the rock green."

Mica of no account.

Mr. Kirwan has justly observed, that the simple addition of mica to any stone, cannot alone entitle it to be placed in the granitic division, as mica does not form a grain, but attaches itself indifferently to many sorts of stones; for there are micaceous limestones, micaceous sandstones, micaceous serpentines, &c. &c. Mica must therefore be totally excluded from the granitels; and felspar with mica, or quartz with mica, can

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crane's bill, *geranium!* But Pliny says himself, xxxvii. 11, *a gruis collo geranites*. See Laet, p. 170, for a print of a Geranites. For the first appearance of the word *granito*, see a former note.

* Fossil Ægyp. p. 7.

only be properly classed with the simple rocks of felspar or of quartz. There are therefore only three genuine structures of granitel; namely, 1. Felspar with siderite. 2. Felspar and quartz. 3. Quartz with siderite.

STRUCTURE I. WERNERITE, FELSPAR WITH SIDERITE.

Wernerite.

The appellation has been derived from this celebrated mineralogist, who well deserves to give his name to one of the most important substances in nature. It is also intended to compensate, while it calls to memory, his noted syenite, a term so ill chosen as to have introduced confusion, instead of illustration. The syenite of Werner, as already mentioned, consists of felspar with siderite, that is, the former is more abundant; but in basalton, or grunstein, the siderite predominates, and gives a black or greenish colour; while Wernerite is generally reddish. Yet the syenite of Werner sometimes contains quartz and black mica, which infallibly constitute a granite; and the stone should, in that case, be said to pass into granite. The appellation of Wernerite is here strictly confined to a mere and sole admixture of felspar with a smaller portion of siderite; and as colours form the meanest of all distinctions, no consideration is paid to that circumstance.

Wernerite of white felspar and black siderite, from Mount Sinai. It sometimes passes into granite; and is reported by tradition to be the stone on which the commandments were engraven.

Of red felspar and black siderite, from the Alps. It is sometimes mixed with mica, or schorl; and if quartz were present, it would then constitute a granite.

Of grey felspar and black siderite, from the ejections of Vesuvius. These substances united, or distinct, may be said to form all the lavas. It is sometimes mixed with garnets or actinote.

Wernerite of grey felspar with black hornblende, forming a vein in granite, on the summit of Mont Blanc. Saussure, § 1987.

Wernerite, from Muhr in Stiria.

Wernerite, in rolled pebbles, from the Lake of Geneva.

Of brownish red felspar and black siderite, from Leipzig.

Of reddish white felspar and black siderite, from the Hartz.

STRUCTURE II. LEHMANITE, FELSPAR WITH QUARTZ.

Lehmanite. This name is given to a primitive substance, from the celebrated Lehman, who first pointed out the distinction between primitive and secondary mountains.

Lehmannite of felspar and quartz, from Cornwall.

The same of white quartz and red felspar, from Scotland.

It is common in the Alps, and other chains of mountains.

Lehmannite of a reddish white, from Sweden*.

Lehmannite, from Grimsel. It is also found in Nassau and Siberia, and near Portsoy, in Scotland. Linnæus, by Gmelin, 214.

Of a yellowish white, from Finland.

Da Costa says, p. 278, that part of Newry, Ireland, is built of this stone, there called *mountain grit*. Another part is of felspar and large green mica.

STRUCTURE III. HENKELITE, QUARTZ WITH SIDERITE.

Henkelite.

The name is derived from Henkel, who may be ranked among the fathers of lithology. The alliances between quartz and siderite seem to be rather uncommon, felspar having been commonly mistaken for the former substance.

Henkelite, from Switzerland.

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* Wall. i. 422.

In Switzerland it often contains garnets.

The same, from Altenberg, in Saxony[*].

The basaltic granite of Wallerius, from Sudermania. It is either black, yellowish, or greenish.

The same, of an iron colour, from Norberg, in Sweden; but this seems rather to belong to the siderous division.

Henkelite is also found in Bohemia, Saxony, Tyrol, Stiria, &c. It is believed that the ancient black and green granites, so called, often consist of this substance[†].

STRUCTURE IV. MINGLED.

The most usual parasitic stones of granitel are schorl and garnets, both composed in a great part of iron.

Wernerite, with garnets, from Vesuvius.

The same, with actinote, from the same.

Lehmanite, with steatite, from the Alps.

Henkelite, with garnets, from the Alps.

The same, with steatite, from the same.

The same, with schorl, from the same.

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[*] Linn. 218.

[†] Launay, Essai sur l'histoire naturelle des Roches, Bruxelles 1786, 12mo. p. 41.

MODE IX. GRANITOID.

Many rocks, inaccurately classed among granites, are reserved for the Composite Domain. Such alone as perfectly resemble granite, but are of a very different modification, are here styled granitoids; and this denomination presents three different structures.

STRUCTURE I. CALCAREOUS GRANITE.

In this rock lime-stone supplies the place of felspar. This substance was first mentioned by Kalm, as forming chains of mountains in Canada. It was afterwards described by Saussure. Werner told me that he regarded it as a truly primitive lime-stone.

Calcareous granite, from the mountains of Canada.

The same, from the vicinity of Mount Cenis. But in the Alps it more commonly assumes the form of gneiss, as at Roth Horn, Mont Cervin, &c.

Reddish calcareous granite, or primitive lime-stone with quartz and mica, from Scotland*.

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* The Journ. de Ph. 1791, mentions a calcareous granitoid, the lime-stone or spar being in globules of an oval form, with crystallised facetts, and compressed horizontally.

STRUCTURE II. ARGILLACEOUS.

This rock is more often the product of decomposition, which changes the felspar into clay.

Argillaceous granite, with quartz, mica, and martial clay, from Hungary and Sweden.

STRUCTURE III. TALCOUS.

From this division talc, and even steatite, must be excluded, as being often mere modifications or decompositions of mica.

Granitoid of felspar, quartz, and serpentine, from Transylvania.

MODE X. GRANITIC PORPHYROID.

Description. In this substance, which is very frequent in nature, some large or distinct crystals of felspar are sprinkled on a base of granitin; and the base being here assumed as the only ground of classification of the substances vaguely called porphyries, it must of course fall into this division. The base may consist of quartz, felspar, and siderite; or quartz, felspar, and mica; or even any two of these substances. Some of the porphyries of Saussure, § 150, belong to this class; but granitic porphyroids are so abundant in all primitive mountains, that it is scarcely necessary to select examples, being a mere variation in the construction of granite or granitin.

Granitic porphyroid, from Mount Cenis.

The same, from Cornwall, Wales, Scotland, the Vosges mountains in France, the Alps, &c. &c.

Saussure, § 155, gives some curious observations on the transitions from granite to granitic porphyry. A great portion of Forez is of porphyry; while the adjacent portion of Auvergne is granitic.

MODE XI. GNEISS.

Distinctions.

When the materials of granite are disposed in thin layers, or plates, the substance assumes the name of Gneiss; which consequently consists of quartz, felspar, and mica. In his two first volumes, published before Werner had introduced greater precision into the science, Saussure has sometimes used the term veined granite, to express what is now denominated gneiss. But in his latter volumes, as already explained, his veined granite differs from gneiss, as presenting only short and irregular veins, terminating in solid masses; while in gneiss the veins are uniform, and regularly divide the whole, as in slate, or in other substances properly schistose. Hence gneiss has also been called schistose granite by the French, and other writers.

In gneiss the mica is generally more abundant, as dividing the substance into regular plates. Sometimes the place of mica is supplied by siderite, which, as already explained with regard to granite, cannot be regarded as altering the denomination, but is only a proof of greater antiquity. The siderite is also sometimes interspersed in thick layers, or even beds. **Red.** One of the most interesting kinds of gneiss, is that with red felspar, sometimes of a wavy or undulated structure, and which is also considered by some as the most ancient. **Contorted.** This, like other schistose substances, is found contorted, or convoluted, in fantastic forms; by some regarded as originating from internal expansion or disturbance; while others consider it as the mere effect of a particular crystallisation.

Primary. Geologists in general have considered granite as the oldest substance, the fundamental rock which supports all the others: the Huttonians however regarding it, on the contrary, as the newest substance, which, being elevated by expansion, has broken the other stratifications. However this be, it is certain that gneiss has, in the grand example of the Alps, been found under granite confessedly primitive; and they are often found alternating with each other. The lofty mountain of Rosa, which only yields in height to Mont Blanc, instead of being composed of arrects or uprights*, that is vertical layers, or plates like the latter, presents, on the contrary, horizontal beds of veined granite, gneiss, and other schistose substances†.

Intermixed with gneiss are sometimes three principal rocks, all regarded as primitive; limestone, siderite either solid or schistose, and porphyry. But these substances equally appear intermixed with granite, only alternating vertically; while in gneiss they present horizontal beds. In the old Egyptian monuments nothing is more common than to find large masses of siderite intermixed with the granite; and even basaltin often penetrates that substance. The Egyptian monuments of mica slate, described by Wad, may perhaps more properly belong to gneiss.

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* In a new science new words must be admitted. Saussure, and others, have long lamented the absurdity of *vertical beds or layers.* Arrects or uprights would supply the deficiency.

† Sauss. 2188.

Primitive lime-stone likewise alternates with granite, and has even been found to assume the granitic forms. The alternation of porphyry with granite is of general observation in all primitive mountains.

Fertile in metals. Gneiss also frequently contains garnets, actinote, magnetic iron, and pyrites. It is, after clay-slate, the most metalliferous of all rocks. The chief mines of Saxony, Bohemia, and Salzburg, are situate in this rock, which, though very common on the Continent, is comparatively rare in Great Britain and Ireland.

STRUCTURE I. TABULAR, OR IN THICK SCHISTOSE FORMS.

This kind is commonly derived from granite, or passes into that rock.

Tabular gneiss, from the Alps.

The same, from the isle of Leuis, in the exterior chain of the Hebudes, Scotland.

STRUCTURE II. LAMINAR.

This is the common appearance of gneiss, and may be divided into two Aspects.

Aspect 1. Plane or level. Gneiss, with red felspar, from the Alps, Norway, Saxony.

Gneiss, with white felspar, from the same countries, Salzburg, Greece, &c. It is a common, and seems a fundamental rock in the Brasils. Mr. Jameson says, that it is found in the isles of Coll, Tirey, and Rona; also in the Shetland isles, and many parts of the main land of Scotland.

Aspect 2. Undulated. This is more uncommon than the former.

Undulated red gneiss, from the Alps of Dauphiny.

The same, singularly contorted, from the same site. This forms a remarkable diversity.

Red gneiss, from Norway.

Grey undulated gneiss, from the same countries.

STRUCTURE III. IRREGULAR.

In this kind the layers intersect each other irregularly, in the form of wedges, &c. It differs from the veined granite of Saussure, because the divisions do not terminate in massy portions, but are continued in oblique and irregular directions.

Red irregular gneiss, from the Alps, Norway, &c.

Grey, from Brasil, and other countries.

STRUCTURE IV. COMPOSED OF TWO SUBSTANCES.

Pinite and Ferberite.

Interesting examples of this kind occur at the mines of Salzburg, and particularly at those of Macugnaga, near Mount Rosa, in the north of Italy. This rock has always been called gneiss, but is composed of thickish plates of quartz, with thin seams of foliated mica, or rather steatite. Gneiss also occurs composed only of felspar and mica. As the first of these kinds has been chiefly observed in Italy, I would propose to call it Pinite, from Pini, an illustrious geologist, who explored the southern Alps. The other may be called Ferberite, an honour due to Ferber, whose travels illustrate many parts of Italy, and the south of Germany.

Aspect 1. Pinite of quartz and steatite, from Macugnaga, near Mount Rosa.

The same, from Salzburg.

Aspect 2. Ferberite, from the Alps, &c.

Gneiss also occurs of quartz and siderite, and of felspar and siderite.

STRUCTURE V. MINGLED.

Grey gneiss, with garnets, from Bohemia.

The same, with actinote, from the same.

The same, with pyrites, from Bohemia.

The same, with different metals, from various countries.

Pinite, with gold pyrites and native gold, from Macugnaga.

The same, with native gold, from Salzburg.

The following examples of various kinds may be added, from Saussure:

A remarkable gneiss, of a bluish grey mica, inclosing long grains of quartz and felspar, which appear like sand, but are in fact crystals more or less regular. § 1221.

A gneiss, composed of irregular layers of white granular quartz, and leaves of a substance intermediate between slate and steatite. § 2044.

A fine gneiss, composed of black mica, approaching in splendour to graphite, intermixed with particles of felspar, and sprinkled with small garnets. § 1732.

A gneiss, composed of grey felsite and grey mica. § 1877.

A gneiss of foliaceous mica, with plates of quartz, sometimes mixed with felspar, forms the mountain which contains the copper mines of St. George. § 1201.

Werner has a large piece of massive granite, inclosing rolled pebbles of gneiss. § 2143. Saussure gives, § 661, examples of granite imbedded in mica slate, or rather gneiss.

In the mountains on the south-east of the valley of Chamouni, the inferior parts are gneiss, while the summits are granite. § 677.

Mount Rosa is wholly composed of veined granite, gneiss, and schistose rocks, from the base to the highest summits. § 2138.

MODE XII. PITCH-STONE.

Characters. Texture, impalpably fine, resinous.

Hardness, basaltic, sometimes felsparic. Fracture, conchoidal; if impure, splintery or coarse-grained. Fragments, irregular and sharp.

Weight, carbonose.

Lustre, from glistening to splendent, resinous. Somewhat translucent; but the black only on the edges.

The colours are various shades of black, and sometimes grey, brown, red, seldom green; but the tints are commonly pale.

Sites. Pitch-stone forms entire mountains in Misnia; and in other mountains of that country it forms large strata, that alternate with porphyry[*]; and as they contain abundance of quartz and felspar, may be called pitchstone-porphyry, for which see the Siliceous Intrites.

Pitch-stone is universally regarded as a primitive rock; but it is also often found secondary, and constituting the substance of petrified wood. In the island of Arran it forms large veins in sand-stone; and it also occurs in Mull and Eig. This curious and important substance seems unknown to Wallerius; but Gmelin, in his edition of Linnæus, has called it *opalus piceus*, and mentioned many of its sites, as Iceland, the isle of Elba, Auvergne, Transylvania, Hungary, the Reisgeberg mountains in Germany, and New Spain. It sometimes occurs in basalt.

STRUCTURE I. COMPACT.

Pitch-stone, from Meissen in Saxony, where it was first observed.

The same, dark red, from Korbetz in Saxony.

The same, spotted with black, from Upper Hungary.

The same, deep red, mingled with greenish transparent opal, from Upper Hungary: Born i. 213.

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[*] Kirwan Geol. Ess. 180.

The same, of a clear blue, from Telkobanya in Upper Hungary.

Green, from Meissen in Saxony.

Green pitch-stone, with adherent sand-stone, from Arran.

The stalactitic kinds, and the petrified wood from Hungary, cannot be said to constitute rocks.

STRUCTURE II. LAMINAR.

Laminar pitch-stone, in thin horizontal layers, alternately white and violet, from Telkobanya.

A laminar kind was also discovered by Mr. Jameson in the island of Arran.

MODE XIII. SILICEOUS INTRITE.

These rocks present crystals of felspar, sometimes quartz, or calcareous spar, in a siliceous ground or base. The most remarkable kinds are those called keralite or hornstein porphyry, and pitch-stone porphyry. They are vaguely classed under the general name porphyry by the German theorists, while the crystals are so unimportant, that in geology they should be

German porphyries.

ranked immediately after the parent rock. The primitive porphyries, according to Werner, are those of hornstein and felsite; to which may be added granitic porphyroid, already described after granite. If a jasper porphyry be found, it must also be admitted. The classical porphyries are unaccountably treated with great disregard, being considered as primitive grunsteins; and the real red porphyry seems as unaccountably omitted. Secondary porphyry includes those with bases of pitch-stone and of clay. The Germans have never been celebrated for clear ideas; and it is truly painful to observe such an utter confusion of important substances in elaborate systems, while the most trifling objects are elucidated with infinite patience and assiduity.

Turpe est difficiles habere nugas,
Stultus et labor ineptiarum.

STRUCTURE I. KERALITE PORPHYRY.

The keralite is generally reddish or greenish. It is sometimes said to form mountains in Siberia and other countries.

STRUCTURE II. FELSITE PORPHYRY.

Saussure mentions a porphyry with a base of earthy felspar. What is called klingstein porphyry, or porphyry slate, by Werner, is the most common and at the same time the most remarkable substance in this division. It has been already described under the Mode Felsite.

STRUCTURE III. PITCH-STONE PORPHYRY.

This has been chiefly observed in Auvergne, where the base is generally a dark or bottle-green pitch-stone, with lighter crystals of felspar. It also occurs in the island of Arran.

In those parts of Auvergne which are truly volcanic (a position to which the most rigid disciples of Werner, who have visited that region, such as Buch and Daubuisson, among others, have been converted), pitch-stone is often found decomposed, and partly reduced to a brownish mass, resembling ochre of iron, and probably arising from the five parts of iron which it contains. This substance will be more minutely described in the division of Decomposed Rocks.

MODE XIV. SILICEOUS GLUTENITE.

Description.

Origin.

Pudding-stones and bricias.

This division will comprehend many important substances of various structures, from the celebrated Egyptian bricia, containing large pebbles of jasper, granite, and porphyry, to the siliceous sand-stone of Stonehenge. The glutenites are of various formations; and the pudding-stone of England would rather seem, as already mentioned, to be an original rock, the pebbles or rather kernels having no appearance of having been rolled in water. Patrin* has expressed the same idea concerning those pudding-stones which so much embarrassed Saussure, as he found their beds in a vertical position, while he argues that they could only have been formed on a horizontal level. This curious question might, as would seem, be easily decided by examining if the kernels have been rolled, or if, on the contrary, they retain their uniform concentric tints, observable in the pudding-stone of England, and well represented in the specimen which Patrin has engraved. But the same idea had arisen to me before I had seen Patrin's ingenious system of mineralogy. In like manner rocks now universally admitted to consist of granular quartz, or that substance crystallised in the form of sand, were formerly supposed to consist of sand agglutinated. Several primitive rocks contain glands of the same substance, and that great observer, Saussure, has called them Glandulites, an useful denomination, when the glands are of the same substance with the rock; while Amygdalites are those rocks which contain kernels of quite a different nature. He observes, that in such a rock a central point of crystallisation may attract the circumjacent matter into a round or oval form, perfectly defined and distinct; while other parts of the substance, having no point of attraction, may coalesce into a mass. The agency of iron may also be suspected, that metal, as appears from its ores, often occurring in detached round and oval forms of many sizes, and even a small proportion having a great power*.

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* i. 154.

On the other hand, many kinds of puddingstone consist merely of rounded pebbles. Saussure describes the Rigiberg, near the lake of Lucerne, a mountain not less than 5800 feet in height above the sea, and said to be eight leagues in circumference, which consists entirely of rolled pebbles, and among them some of pudding-stone, probably original, disposed in regular layers, and imbedded in a calcareous cement. The pudding rocks around the great lake Baikal, in the centre of Asia, present the same phenomenon; but it has not been observed whether the fragments be of an original or derivative rock. The derivative are supposed by theorists to have proceeded from vast currents, flowing from the primitive mountains, as on the diminution of the primitive waters these mountains first appeared in the shape of islands, while the remaining parts of continents required many ages before they emerged from the ocean. It is remarkable that this corresponds with the most ancient ideas; for the Argonauts are represented as sailing from the Euxine Sea to the British Ocean; and Cesar describes Britain as an island shared between land and water, the rivers being, as in most countries newly inhabited, of enormous size.

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* Buffon had on his estate a large and important mine, in which the iron ore was solely in the form of peas.

Sand-stones.

The siliceous sand-stones form another important division of this mode. They may sometimes, as already mentioned, be confounded with granular quartz, which must be regarded as a primary crystallisation. The sand, which has also been found in micaceous schistus, and at a vast depth in many mines, may be well regarded as belonging to this formation; for it is well known, that if the crystallisation be much disturbed, the substance will descend in small irregular particles.

Siliceous sand-stones are far more uncommon than the calcareous or argillaceous. The limits of the chalk country in England are singularly marked by large masses of siliceous sand-stone, irregularly dispersed. Those of Stonehenge afford remarkable examples of the size and nature of those fragments, but the original rock has not been discovered. Trap or basaltin often reposes on siliceous sand-stone.

STRUCTURE I. LARGELY GRANULATED.

Bricia of Egypt.

This division of course includes siliceous bricias and pudding-stones. The most eminent and singular of these occur in Egypt, in the celebrated universal bricia of the Valley of Cosseir, and in the siliceous bricia of the same chain, in which are imbedded those curious pebbles known by the name of Egyptian jasper; and which also sometimes contains agates. This last, from its colour and decomposition, might perhaps be more properly classed among the Siderous Intrites; but till a proper analysis be formed, it may as well follow the universal bricia, to which it may be regarded as a remarkable rival. Bricias, with red jasper, also occur in France, Switzerland, and other countries; but the cement is friable, and they seldom take a good polish. All these rocks present both round and angular fragments, which shows that the division into bricias and pudding-stones cannot be accepted: a better division, when properly ascertained, would be into original and derivative glutenites. In a geological point of view, the most remarkable pudding-stones, which might more classically be called Kollanites, from the Greek*, are those which border the chains of primitive mountains, as already mentioned. The English pudding-stone (for a particular account of which see the Anomalous Rocks) is unique; and beautiful specimens are highly valued in France, and other countries. It is certainly an original rock, arising from a peculiar crystallisation, being composed of round and oval kernels of a red, yellow, brown, or grey tint, in a base consisting of particles of the same, united by a siliceous cement. A coarser kind also occurs, consisting of grey pebbles in a far more abundant grey cement; it

English pudding-stone.

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* Κολλα, cement; the more proper, as it also implies iron, often the chief agent.

seems harder than the pebbles themselves, which are apt to drop out entire, the circumference of crystallisation having been as exactly defined by the laws of attraction, as in the detached peas, or little geods of iron, already mentioned. Patrin supposes that they were formed separately, and afterwards cemented by siliceous matter; but as many other crystals are easily detached from the gangart, there seems to be no necessity for this supposition.

Pebbles. Saussure, § 1943, has treated the utility of the study of pebbles. In the glens of high mountains they are of the same stones with these mountains; but in the plains, and the large adjoining valleys, they are of quite a different nature, and seem to have been transported by some great revolution.

"It is an important observation for the theory of the earth, that in the upper parts of valleys surrounded with high mountains, no rolled pebbles are found, which are foreign to the valley itself in which they are met with; those observed are never other than spoils of the neighbouring mountains. In the plains, on the contrary, and at the openings of valleys which adjoin the plains, and even some way up the sides of the mountains which border on these plains, pebbles and blocks are found, which might be said to have fallen from the heaveins, so different is their nature from every thing found in the environs."*

Triumphal arch.

The same able observer describes, § 957, the triumphal arch of Augustus, at Aosta, as constructed of large squares of a singular kind of pudding-stone, or large sand-stone, being an assemblage of fragments, mostly angular, of all sorts of primitive rocks, quartzy, slaty, and micaceous, the largest about the size of a hazel nut. The cement he does not mention. Most of the ancient edifices of Aosta and its environs are of this stone, and the common people are persuaded that it is a composition, as was also the first general belief concerning granite; but Saussure observed the rocks in the mountains on the north, above the road to Yvree.

Aspect 1. Green universal bricia, from the old Egyptian monuments.

The celebrated sarcophage, in the British Museum, is of this stone. As it chiefly consists of green jasper, it may perhaps more properly belong to the Siderous Glutenites.

The same, from the Valley of Cosseir.

Aspect 2. The same, with rolled granite and angular fragments of porphyry, from the same.

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* Sauss. 717.

This is very rare, having been rejected by the ancient artists. There are also other diversities.

Aspect 3. Egyptian kollanite, or pudding-stone, containing balls of brown jasper, and sometimes agates, with angular or round crystals of unctuous quartz, in a brown ferruginous base, also of an unctuous appearance, owing to the abundance of that quartz which seems united with iron in forming the cement, from the valley of Suez.

Aspect 4. The same, without the balls of jasper or agate, a fragment of the celebrated statue of Memnon, in Upper Egypt.

Aspect 5. Jasper bricia, intermixed with other stones, from Forez, in France.

The same, from Switzerland.

Aspect 6. Quartz bricia, consisting of fragments of that substance joined by the same cement, from Smoland, in Sweden.

STRUCTURE II. SMALL-GRAINED.

Sand-stones. In the Mode of Glutenites it would be difficult, as the celebrated Romé de Lisle has long ago remarked, to fix a precise boundary between pudding-stones and large-grained sand-stones.

Even the Egyptian kollanite above mentioned might, without the balls of jasper and agate, be considered as a large-grained sand-stone, singularly formed of unctuous quartz. The large-grained siliceous sand-stones are however far more rare than those of a finer construction. It is not unusual to find in them, as in other sand-stones, nodules or veins of green earth or chlorite, a substance also common in sand; and, like its parent iron, more widely diffused than is commonly imagined.

Mr. Kirwan's account of siliceous sand-stone is too interesting to be omitted.

"This stone is generally reckoned among the secondary; yet where no organic remains are found in it, where it does not rest on any secondary stone, where no secondary stone enters in its composition, I do not see why it may not be aggregated to the primary. Sand, amongst the convulsions occasioned by the volcanic eruptions before the creation of animals, must have been formed; and even independently of these, some must have been deposited, during or after the crystallisation of the various substances contained in the elastic fluid. See 5th Sauss. 294. Mount Jorat and the Coteau de Boissy, near Geneva, 1 Sauss. 246. 349, seem to be primeval; so also the sand-stone found in the island of Bornholm, 5 Berl. Beobacht. Also that mentioned in 2 Sauss. § 763, which graduates into gneiss, must also be primary, though it contains tumblers (caillous roulés). The sand-stone near Lischau, in the vicinity of Prague, graduates into horn-stone, and even into granite. Mr. Rosler even thinks it to have been originally a granite, whose felspar was decomposed into clay, which then cemented the quartzy grains; a most ingenious and probable conjecture. 1 Bergbau. 339 and 341.

“ Most of the arenilitic mountains of Bohemia, on both sides of the Elbe, appear to be primitive, by Reuss's description. See Reuss, 96, &c. In the east and north parts of Bohemia, many of them are split, or form columns resembling basalts. 2 Berg. Journ. 1792, 70.

“ In Bohemia, sand-stones with an argillaceous cement alternate with those whose cement is siliceous. Reuss. In Kinnecula, the lowest stratum incumbent on granite seems also to be primitive; over it the secondary strata repose. 29 Swed. Abhand. C. 29. 5 Bergm. 126.

“ In Brainsdorf, in Saxony, it passes into schistose mica, and alternates with argillite. 2 Crell. Beytr. 64. In Reigelsdorf it forms the fundamental rock on which semiprotolite immediately lies, which is covered with other secondary strata. 2 Berg. Jour. 1790, 285. Near Oyben, and in other tracts of Saxony, no petrifactions or conchylaceous impressions are found in it, though in that of Perna, adjoining, they are found. Charp. 24 and 26: it sometimes reposes on horn-slate, Charp. 24.

"The mountain Steinthal, in the Vosges, of red sand-stone, is considered, by Baron Diedrech, as primeval. 2 Diedr. *Gites des Minerais*, 209, 210. The sand-stone mentioned in 6 Sauss. 81, which alternates with primitive lime-stone, must also be primitive."*

Brongniart, in his Mineralogy, has adopted rather a singular distribution of the *grès*, that is, grit or sand-stone, and arranges it immediately after quartz. He informs us, in a note, that he only here describes the pure and homogeneous sand-stone, composed solely of quartz; the other stones, commonly called sand-stones, being placed among the rocks, where they will be described under the name of *psammites*. The stone which he defines is composed of very small grains of quartz, "agglutinated by an invisible cement." It has therefore the hardness and infusibility of quartz in its grains; but its texture changes the aspect of its fracture. This fracture, always granular, sometimes scaly and even shining, without ceasing to be granular, is sometimes level, sometimes conchoidal. When this grit is solid, it strikes fire with steel; when friable, its hardness can only be judged by the ease with which it scratches steel, and the hardest glass; but it does not scratch beryl. These characters suffice to distinguish it from dolomite, granular sulphate of barytes, emery, and some horn-stones, the only substances to which it bears some resemblance.

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* Geol. Ess. 209.

He then enumerates several varieties: as, 1. the *grès lustrè* of Haüy, which betrays its granular texture by its translucency. It forms beds at Montmorency, near Paris, and arrects near Cherbourg. The very ingenious Gillet discovered that, under a violent blow of the hammer, a regular pyramid or wide cone is often extricated. 2. The white sand-stone found to the south of Paris, and often used for grindstones; while that of Fontainebleau, which is in very thick horizontal beds, serves to pave the streets of Paris. It is sometimes mixed with lime, which makes it effervesce; but this alteration is more rare than is commonly conceived, and is only observed in the quarries called Belle Croix and Nemours, where are also found the curious crystals in which the quartzose sand assumes the calcareous form. 3. Ribbon-grit, so called because various colours are displayed in straight lines or in zigzag: it is common in Thuringia and in Magdeburg. 4. Red grit, which is of a coarse grain, and the particles united by iron. This is the deadlayer of the Germans, which it is ridiculous to class here, as it totally differs from his introductory definition. 5. Flexible grit of Brazil. 6. Filtering-stone, full of numerous and irregular pores, but seemingly composed of quartz only. It is found in Saxony, Bohemia, New Spain, and the Canaries: it is also found in Spain, in Guipuscoa, where they make statues with hollow heads, so that water being poured it passes through the eyes, and the figures seem to weep.

Such, he says, are the principal varieties afforded by grit or sand-stone, considered as homogenous, and not as a mingled rock; and he adds some examples of sand-stones originally crystallised with that texture: but when he includes the red ferruginous sand-stone, he forgets that it sometimes contains fragments of porphyry and other rocks; and parts of the remainder of the article refer to argillaceous and even calcareous sand-stone. This stone therefore, which he places between quartz and flint, ought to have been classed with the former under the usual denomination of granular quartz.

Mr. Jameson has observed*, that there is a sand-stone cemented by quartz; so that a chemical and mechanical formation may occur in the same rock. He mentions, in another work*, that there is a vein at Lautorberg, in the Hartz, nine fathoms wide, filled with quartz in the state of sand. Pepits of copper are intermixed, and the miners only use picks. It is crystallised, and not the product of decomposition; if permeated by a siliceous juice, it would have been sand-stone. Fine examples of siliceous sand-stone may be found in Salisbury Craigs, near Edinburgh.

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* Geog. p. 39.

Aspect 1. Coarse siliceous sand-stone, from Sweden, &c.

Aspect 2. Fine, from Stonehenge, &c.

The same, from Salisbury Craigs, near Edinburgh.

Elastic siliceous sand-stone, sometimes called elastic quartz, from Brazil.

Siliceous sand-stone, like most other rocks, is also found schistose and laminated.

Add the following varieties, from Saussure:

A remarkable sand-stone, composed of very small grains of white quartz and felspar, with little specks of greenish mica, which absorbs water with avidity, becoming greenish and transluoent, so as to resemble a felsite or jad. § 1242.

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* Dumfrieshire, from Voigt.

A sand-stone of a violet colour, common between Antibes and Frejus. It contains bits of porphyry, and fragments of other sand-stones. § 1462.

Siliceous sand-stone, which resembles gneiss, and alternates with lime-stone and slate. § 763.

Beds of a beautiful sand-stone, composed of adherent grains of quartz. § 1370.

A green sand-stone, of little fragments of quartz, in a cement of felsite. § 1539.

Sand is not only the produce of crystallisation, but may even be produced artificially by an operation of that kind. § 1375.

Fallen mountain.

In 1751, a mountain between Sallenche and Servoz fell down, with such a thick and horrible dust, diffused to the distance of five leagues, that people thought the end of the world was arrived. It was undermined by a lake; and vast masses of stone fell down day and night with a noise like thunder. Among the ruins of this mountain Saussure found the following singular sand-stone:

"Fragments of a kind of greenish sand-stone, externally spotted, very hard, and of a very fine grain*.

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* The bricia of Rosenberg, which fell in 1806, somewhat re-

"This sand-stone effervesces with aquafortis very weakly; but the effervescence may be increased, if the acid in which it is put is heated; but which does not deprive it either of its coherence or its hardness, for it strikes fire, even after this proof. The grains of fine sand and mica, of which this sand-stone is composed, must then be united by a quartzy or argillaceous gluten, and the calcareous particles which produce the slight effervescence that was observed, be infiltrated, and deposed as a foreign body in its external pores.

"I have seen in Italy antique works, which were said to be basalt, but which appeared to me of a kind of rock very similar to this, and consequently very different from real volcanic basalts. A statue of a child, that is shown in the gallery of Florence under the name of Britannicus, and which is said to be of basalt, is most likely of this same kind of rock. I have had a piece of this sand-stone worked; and the kind of polish which it has taken, perfectly resembles that of this statue."*

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sembles the green bricia of Egypt, as I am informed by an ingenious French traveller.

* Sauss. § 493.

Andes near Quito.

DOMAIN III.

ARGILLACEOUS.

◆

ARGIL.

THIS earth is obtained in the state of greatest purity from alum, which is a mixture of argil and sulphuric acid. If it contain oxyd of iron, as is frequently the case, it emits a particular smell, when breathed upon, well known by the name of an earthy smell.

With heat it loses its water, and diminishes in bulk; but a very violent heat converts it into a white amel. When combined with lime it easily enters into fusion.

Argil, also called Alumina by recent chemists, is of great utility, as forming the basis of many manufactures, such as brick, porcelain, and earthenware. It constitutes 98 parts in the 100 of corindon; under which division are now classed the most perfect of the precious stones, after the diamond, such as the sapphire, ruby, and oriental topaz. It is hence not only one of the most noble, but one of the most useful of the earths; loam or fertile soil being a mixture of about 30 parts argil with 70 of fine sand; while mould chiefly consists of animal and vegetable remains.

In the primitive rocks argil is an important feature, forming about a fifth part of felspar, and a third of mica. The most ancient slates abound in argil. It is often so homogeneous that it cannot be regarded as the waste of former mountains, but a pure deposit of primeval waters. In the primitive schisti however there is still a great preponderance of sand; and the glossy appearance may sometimes proceed from decomposed mica.

The argillaceous rocks are mostly of a simple and uniform appearance, and do not admit the numerous modifications of some other substances. This earth is chiefly eminent in gemmology, where it constitutes some of the most beautiful varieties. The argillaceous rocks are never crystallised, and present but small splendour in their appearance*; hence they are very seldom used in the ornamental arts, and are chiefly important in a geological point of view, where they often rank among the most important primitive substances. Yet even in this light they have not been treated with the attention and minute investigation which have been bestowed upon the Siliceous and Calcareous Divisions.

The essential part of the argillaceous

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* Brongniart, i. 512, informs us, that as the argils never crystallise, they afford no *species*. A further proof that this term is foreign to mineralogy.

rocks being alum, it seems the most natural progress to begin with those substances which chiefly supply commerce with that earth.

MODE I. ALUM ROCK.

Of this there are two very different structures; the alum rock of Tolfa, which yields what is called the Roman alum, and the common aluminous slate.

Alum of Rocca.

It has been said by some that the rock alum of the middle ages derived its name from a town in Syria, called Roch or Roque, *Rocca*; but a pilgrim having observed the same kind of rocks near Civita Vecchia, the Pope founded the celebrated manufactory which supplied Europe for some time*. The description of the latter has been given by several mineralogic authors under the class of salts; but it may be interesting to present the accurate account of Ferber, who mentions, that the rocks which yield the Roman alum constitute white, high, and argillaceous hills, of a compact structure, and with scarcely any visible horizontal beds; but there are some fissures filled with quartz, yielding what are called Tolfa diamonds*. He afterwards proceeds:

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* Wall. ii. p. 43. Alum is classed among the salts by chemical writers, and is called sulphate of argil.

Tolfa.

"The alum hills are very high, shining, white rocks, separated by a long valley, and large excavations, which are made in the following manner. The workmen descend by ropes to the steep rocks; thus suspended, they bore blasting-holes, fill them with cartridges, free the rocks which by former blastings are loosened, and then are pulled up again. The firing of the powder is done by dry branches and leaves, which experience has taught them to throw from on high to any place below.

"The alum rock is whitish grey, or chalk-white; extremely compact, and remarkably hard. Scraped with a knife it yields an argillaceous powder, which does not ferment with any acid, as it is penetrated by the vitriolic acid, and composed of an argillaceous substance. There are some bluish grey shivery pieces, which are rejected as unfit, and probably are the remains of the natural argillaceous stone, before it was sufficiently imbibed and whitened by the vitriolic acid. In some cracks appears a chalk-white ductile clay. Some pieces are bluish grey, with white spots, produced by the acid. They much resemble the half-dissolved black lava in *Solfaterra*, with white, garnet-like, schorls; with this difference, that in Solfaterra the subterraneous acid worked upon lava, and here upon an argillaceous bluish stone. The acid seems in this place likewise to be produced by subterraneous steams, which, penetrating the argillaceous stones, changed them into alum ore. I could not ascertain whether there be near Tolfa ancient volcanoes; but I saw lava-fragments in the wall under the boiling-pans, and therefore they cannot be far distant.

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* Italy, 206.

"By all this it appears that the aluminous rock at Tolfa is an indurated clay, having imbibed and been whitened by a vitriolic acid, and contains some few calcareous particles, which, in the alum manufactories, precipitate in the wooden rills or troughs, under the form of selenites. It is a compact and sound rock, neither stratified nor shivery and slaty. Some nearly perpendicular white-grey quartz veins, three or four inches wide, cross it from top to bottom; and in some places appears in the midst of the white rock a red mixture, as it were, of a *colcothar vitrioli*, or *crocus martis*, or spotted pieces, which resemble red and white marbled soap.

"The blasted stones are calcined in furnaces, which have an inverted conical form. They are in the open fields close together, surrounded and separated by a covering of turf and mould. The upper diameter is about eight feet. They are filled at the bottom with wood, and then heaped with alum-stone, which appears above the furnaces as an accumulated cone, nine or ten feet high, which is nearly answering to the depth of the furnace. Then fire is set to the wood by a square vent near the bottom, and the whole is burnt down in about three hours' time; which is, as they told me, the requisite time for burning: after which the heated stones are carried to the boiling-house, distant about one Italian mile from the quarries. Here they are put into large pits, or square wooden reservoirs, half sunk into the ground; where they are steeped in a convenient quantity of water, which, after sufficient dissolution of the alum, is by troughs conveyed into the alum-house, and in large square wooden settlers, that the dregs may settle at the bottom. This done, the clear lixivium is poured into brass pans, and, after sufficient boiling, conveyed into wooden coolers, on whose sides the alum crystallises white and reddish. Before the inspissated brine be conveyed into the cooler, they stop it for some time in the troughs, in order to facilitate the precipitation of a reddish selenite; and in the boiling they mix in the liquor some lime and urine*.

"The supports of the pans are made of a grey lava, with large white crystalline schorl-prisms, whose quantity exceeds the mass of the ferruminating lava. It is found, as they told me, in large loose pieces, at nine or ten miles' distance from Tolfa; and it resembles much the lava of a volcanic hill called St. Fiora, in Tuscany, which I have seen, and shall describe in my following letters.

"The Tolfa alum-mines are said to have been discovered in former times by a man, who, having been long time a slave in Turkey, and worked there in some alum works, guessed by the *ilex aquifolium*, common about Tolfa, that there must be alum in the neighbourhood. But this shrub is found in many places where no alum is discovered."

It is evident from this account that the alum rocks of Tolfa are very different from aluminous slate, which shall be afterwards described.

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* "If this be the case, the selenite is in no respect a substantial part of the Tolfa alum-stone, as the author seems inclined to suppose." Raspe the translator, whose language is far from pure.

STRUCTURE I. MASSIVE ALUM ROCK.

Characters.

Texture, granular; on a large scale somewhat stratified.

Hardness, gypsic. Fracture, earthy or uneven. Fragments, amorphous, not sharp.

Weight, carbonose.

Lustre, dull. Opake.

Colour, greyish white, greyish yellow, or yellowish white. Bergman found it to contain about 43 of sulphur and other volatile matter; 35 argil; 22 silex; and some iron.

Mr. Kirwan says, that veins of this kind have been discovered in Bretagne; but when he supposes that the Roman alum also runs in veins, he contradicts the ample account of Ferber, no inaccurate observer, who formally and repeatedly informs us that it is extracted from a rock constituting hills, and containing veins of quartz*.

STRUCTURE II. ALUMINOUS SLATE.

Characters.

This substance abounds in many countries. Werner divides it into the common and the glossy.

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* The name Roman alum is now also given to the finest, wherever fabricated.

Texture, schistose.

Hardness, gypsic. Fracture, sometimes straight, sometimes waved. Fragments, laminar.

Weight, from carbonose to granitose.

Lustre, glimmering; the glossy kind glistening. Opake.

Colour, greyish or bluish black. It is the black slate celebrated by the vulgar for its medical properties.

Aspect 1. Common. This is generally used in the British manufactories of alum. The finest specimens are from an old coal-mine near Glasgow, in Scotland.

Alum slate, from the vicinity of Glasgow.

The same, with some small appearances of the alum.

The same, more expanded or decomposed, with beautiful fibres of alum, like amianthus.

The bituminous shale of Kirwan*, though he ranks it with alum slate, seems to belong to a different mode. Pyrites sometimes decompose to alum, vitriolic acid being formed by the oxydised sulphur, which, by exposure to air and moisture, slowly re-acts on the argil, and forms alum.

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* ii. 19.

Aspect 2. Glossy. This, as already mentioned, has rather a metallic appearance, and is sometimes tarnished like peacock coal. In the north of France it is sometimes found singularly hard and compact.

Aspect 3. Alum earth. This is found compact, and of a brownish black colour.

MODE II. CLAY SLATE.

Distinctions.

This must not be confounded with the argillaceous schistus of Kirwan, which is here called slate, and assigned to the Siderous Domain; while clay slate is the schistose clay of Kirwan, which he also calls shale, and which is often found over coal, bearing vegetable impressions.

The argillaceous schistus, or argillite, of Kirwan, is the *thonschieffer* of Werner; while, by too nice a distinction, his *schiefferthon,* the slate clay of Kirwan, is our clay slate. Brochant terms it *argile schisteuse.* It is less hard and weighty than siderous slate, adheres to the tongue, and softens in water. But all their descriptions chiefly refer to that kind which is found in coal-mines; while the most important division is that which forms entire mountains, as among the Andes in South America, and in many other metallic regions. This is in general very far removed from siderous slate, which is commonly quarried as valuable in architecture; being less ferruginous, and far more coarsely schistose, so as sometimes to be even confounded with grauwack. The necessity of new denominations in mineralogy is also apparent from this example; for while we are told by Mr. Kirwan that the Andes chiefly consist of primeval blue argillite, one would expect an universal repository of slates for architecture; while in fact none such appear, and the substance is a coarse clay slate, slightly impregnated with iron. In like manner Mr. Jameson must mean the present substance when he gives us the following information.

" Clay slate is one of the most metalliferous of the primitive rocks. It contains many of the venigenous formations that occur in the preceding primitive rocks, as tin, lead, cobalt, and silver. Very considerable metalliferous beds also frequently occur, and these contain copper pyrites, red copper ore, copper green, copper azure, malachite, iron pyrites, magnetic pyrites, glance cobalt, grey cobalt ore, arsenic pyrites, blend and lead glance. Gold also occurs in this formation, and it is said also cinnabar.

"It is a very widely-extended rock. In this country it skirts the Highlands, from Lochlomond, by Callender, Comrie, and Dunkeld; in the whole of that extensive district resting on, and gradually passing into, mica slate; the same appearances are to be observed in many other quarters in Scotland. On the Continent of Europe it has been traced through a great extent of country: thus it occurs in Saxony, Bohemia, Silesia, Franconia, Bavaria, the Alps of Swisserland, Austria, Hungary, and many other parts in Europe. It occurs also in considerable quantity in North America, as Pennsylvania; also in immense quantity in South America; thus it is said that nearly the whole country between Potosi and Lima is composed of it."*

It is self-evident that a wide distinction should be made between this important and universally diffused substance, and the siderous slate which is used in architecture.

In his mineralogy, Mr. Kirwan seems to have blended the primary and secondary argillaceous schistus, when he mentions that it sometimes bears impressions of vegetables and shells†; but in his geological essays, which are valuable as they present a mass of information, compiled with great labour from German authors little known in this country, he has distinguished them, by the divisions of his work, into primitive and secondary rocks. His account of the primitive clay slate is as follows:

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* Geognosy, 125.

† In the vale of Chamouni it is found impressed with ammonites.

Kirwan's account.

"It forms whole mountains, Voigt Prack. 38. But more commonly only partially enters into them, as in Saxony, Charp. 175. Or entire strata, as at Zillerthal, in Tyrol. Its mountains are of gentle ascent.

Primitive.

"There is no doubt of its being often primitive, for in Saxony it frequently alternates with gneiss and schistose mica. 3 Helvet. Mag. 190. 1 Berg. Jour. 1792. 536. And with primitive lime-stone. 8 Sauss. 144. And in Hanover granular lime-stone is found betwixt its layers. 1 Berg. Jour. 1791. 306. We have also seen that both granite and gneiss often rest upon it. Both Karsten, 3 Helvet. Mag. and Monnet, in 25 Roz. 85. sufficiently establish this distinction. There are two sorts of it particularly to be attended to, the *harder* and the *softer*; the harder border upon, and often pass into, siliceous schistus, or basanite, or hornblende slate. The softer border upon, or pass into, trap, or wacken, or rubble stone, or rubble slate, or coticular slate, or indurated clay, and the harder often graduate into the softer. 3 Nev. Nord. Beytr. 169. Or border upon the *muriatic genus*, and pass into schistose chlorite, or schistose talc, or gneiss, or schistose mica. It often contains quartz, both in veins and betwixt its laminæ. Voigt Prack. 41. More rarely felspar, schorl, garnets or hornblende, and granular lime-stone. Berg. Kal. 205, 206. The softer sorts are remarkably metalliferous. Berg. Kal. Voigt Prack. 40. The famous mountains of Potosi consist of it chiefly. 1 Berg. Jour. 1792. 545. In Saxony it is found in primitive lime-stone. 2 Berg. Jour. 1792, 134; and often mixed with it, as in Leske, G. 328. It is so much the more siliciferous as it approaches more to granitic mountains. Lasius, 121. It passes into rubble stone. 2 Berg. Jour. 1788. 498. In the argillites of the Pyrenees no organic remains are to be found. Descrip. Pyren. 27. Saussure found it in the snowy regions of Mont Blanc. 7 Sauss. 256."*

Of the secondary argillite, or clay slate, Mr. Kirwan gives the following description:

Secondary.

"There can be no doubt but argillite is frequently of secondary origin; Ferber acknowledges it to be partly primeval, and partly secondary. 4 N. Act. Petropol. 289. Gruner the first being of a finer grain, while the latter seems to graduate into the stone used for sharpening scythes, and which, from the coarser grains of silex, becomes an argillaceous sandstone. Patrin informs us that hones are found in the mountains of Jura, and the Vosges*; and the substance was found on digging a well an extreme depth, at Hampstead, near London.

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* Geol. Ess. 183.

Chinese cameos.

Clay slate has seldom been used for ornamental purposes; but the Chinese, a most intelligent and ingenious people, and amounting, by the most moderate computation, to about two hundred and thirty millions of souls, or one-third of the human race, have rivalled the ancients in converting to utility and ornament numerous articles of the mineral kingdom; and, among the rest, this substance has not escaped their attention.

"The cameo slate of the Chinese is also a primitive argillaceous schistus, of a very fine paste, softer than the hone, and which presents three, or even four, successive layers, very thin, of different colours very neatly divided, and strongly adhering to each other.

" The Chinese artists have availed themselves of the disposition of this stone. They form basso-relievos or cameos of it, of most exquisite workmanship, and sometimes of considerable size. I saw a picture made of it in the Imperial Cabinet of Petersburg, more than two feet in length, representing a landscape, with figures of men and animals. These objects were of three different colours, white, green, and red; the ground, of a coffee colour, made the fourth. Beautiful specimens of the Chinese cameos are found in several cabinets at Paris, and especially in the collection belonging to the Council of Mines."*

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* i. 123.

A fine piece of the same kind appears in the grand collection of M. Dedrée, brother-in-law of Dolomieu. Some may also exist in England; but although we carry on the chief trade with China, there are not so many singular Chinese articles in London as in Paris. The Chinese musical balls, for example, are not known in London. They are used by the Mandarins when inclined to sleep, the mere heat of the hand producing various sounds, like those of the harp of Eolus. Faujas had one dissected, when it was found to consist of minute wires of steel, of various sizes, disposed according to some artificial rules. The first Parisian artists acknowledged their inability to produce such a singular machine.

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* Patrin Min. i. 124.

Antique. Clay slate was also occasionally used in the arts by the ancients, for Wad, in his catalogue of the Borgian Museum, has mentioned a fragment of a small statue of a bluish grey slate, the surface being white from decomposition. There are also heads of battle-axes, of a grey clay slate, veined with a deeper colour, probably from some island in the South Sea.

This substance is often singularly contorted in various fantastic forms, both on a large and on a small scale.

Gmelin supposes that the softer clays arise from the decomposition of the harder; and he says that rock clay is sometimes used in building*. Dr. Buchanan, in his travels in the south of Hindostan, observed a kind of clay, which, when dug up and dried, becomes as solid as brick, whence he has not improperly called it
Laterite. *laterite*.

The materials concerning clay rock and clay slate are unusually scanty, not only because they are seldom used in the arts, but because even geologists have paid far more attention to the granitic and calcareous rocks than to the argillaceous, which are however of vast extent and great importance.

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* Linn. 137.

Andes.

The most authentic and scientific account of the construction of that vast chain of mountains the Andes, is contained in the travels of Helms, a German mine-master, who was appointed to introduce Born's method of amalgamation into the Peruvian metallurgy. He remained in that country from 1789 to 1793, and in 1798 published his Journal, containing his daily observations made on the spot. In the English translation, or rather abridgement, the translator, unaware of their consequence, has omitted many important particulars; but enough remains to show the construction of this magnificent and singular chain, which astonished our author by such abrupt irregularities, and such various alternations of their component parts, as he had never beheld in the mountains of Hungary, Saxony, or the Pyrenees. In no country, he adds, does a revolution of nature appear to have been so general as in South America, and the traces are every where discoverable.

After further premising that he travels from Buenos Ayres to Lima, across the chief region of the Andes, his scattered information on this important topic shall be brought before the reader in one point of view.

"During the journey to Tucuman we found

the mountains composed of primitive granite, but as we proceeded, the granite became intermixed with argillaceous slate of various colours; that however which chiefly predominates in the Cordilleras is of a bluish cast, as far at least as we had an opportunity of examining them. Strata of lime-stone, and large masses of ferruginous sand-stone, are in many places superincumbent on the argillaceous slate. We likewise found on the road coal, gypsum, and rock salt; the last even on the summits of the most elevated ridges."

In the bed of the river Rosario he likewise observed blue clay slate; and he was surprised to find the highest snow-capt mountains, within nine miles of Potosi, covered with a pretty thick stratum of granitic stones, rounded by the action of water; while there is a continual descent to Tucuman, where the granitic ridge ends: and from Tucuman to Potosi it consists of simple clay slate.

"The mountain Potosi, at whose foot the city is built, resembles a sugar-loaf: it is almost eighteen miles in circumference, and chiefly composed of a yellow very firm argillaceous slate, full of veins of ferruginous quartz, in which silver ore, and sometimes brittle vitreous ore, are found interspersed."

On his journey from Potosi to Lima, he found at Alcacado clay slate, interspersed with masses of granite; and afterwards red sand-stone on the clay slate. They afterwards alternate, and the slate is covered with thin moss.

The rich city of La Paz is built at the bottom of the highest part of the Andes, covered with everlasting snow. In a fragment of the rock, being a glutenite of yellow clay and rounded flints, lumps of pure gold were found, weighing from two to twenty pounds. Puno, which is also one of the highest parts of the Andes, presents mountains of fine clay slate, abounding in rich ores of gold and silver.

Passing through Cuzco he arrives at Carretas. "The base of argillaceous slate is covered with an alluvial superstratum, which consists of marl, gypsum, lime-stone, sand, a large quantity of rock salt, and of fragments of porphyry, &c. in which pure silver and rich silver ores occur in abundance. There are few instances in Europe of such mountains so generally abounding with the precious metals, or their ores, as in this quarter of the globe. The whole ridge appears to be full of alluvial veins of heavy silver ores, in which pieces of pure silver, solid copper, and lead ore, occur, intermixed with a great quantity of white silver ore, and capillary virgin silver. Thirty-six miles before we reach

Guancavelica, behind Parcos, lie mountains of weather-beaten argillaceous slate, mixed with sand. The sections of these mountains consist entirely of separate, more or less sharp-pointed, pyramids of a flesh-coloured sand-stone.

"The ridge of mountains covered with snow, over which the road to the Pacific Ocean passes, consists of simple sand-stone, through which metallic veins, in some places with quartz or felspar, in others with steatite and schorl, &c. openly appear. On the contrary, the chain of mountains to the north of Guamanga and Guancavelica is said to consist, to the extent of one hundred miles, of simple lime-stone, and equally abounds with metallic ores, especially in the province of Tarma."

"Behind Guancavelica the mountains gradually become composed of less various materials, and at last consist only of simple sand-stone, with layers of marl, lime-stone, and spar, or of simple lime-stone; they continue however equally rich in gold, silver, quicksilver, rock-salt, &c."

It further appears from the original work that the clay slate, which chiefly composes this magnificent chain of mountains, is of various beautiful colours; blue, dark red, flesh colour, grey, and yellow.

In chemical analysis it has sometimes happened that the chemist has ably performed his task, but has mistaken the name of the substance. In like manner it was here necessary to identify the rock, before proceeding to its description. It has before been observed that it may be divided into two kinds, which at the same time vary considerably in their structure, namely, primitive and secondary.

STRUCTURE I. PRIMITIVE CLAY SLATE.

Texture, schistose, sometimes in thin layers, but more generally they are thick and coarse; fine-grained, sometimes almost impalpable. Characters.

Hardness, marmoric, sometimes gypsic. Fracture, slaty, sometimes approaching to earthy. Fragments, amorphous, tabular, with sharp angles.

Weight, carbonose to granitose.

Lustre, sometimes dull, often silky. Opake.

The colour is most usually grey, of various tints; but it may also be found of a straw yellow, and various hues of red. It sometimes presents streaks of a bluish white, or is mottled with various illinitions.

Yellow clay slate, from Potosi.

Grey, from the Andes, Saxony, Scotland, and other metallic countries.

Pale blue, with cubic pyrites, from Yorkshire.

The same, with dendritic pyrites.

The same, singularly convolved, from the Alps of Dauphiny, and many other regions.

Thick clay slate, intersected in all directions with veins of quartz, from Scotland.

The same, with calcareous spar, from Durham.

The same, with veins of quartz containing emeralds, from the celebrated emerald-mines at Muzo, in the Viceroyalty of New Grenada. It does not appear that Peru ever produced any emeralds.

Massive clay slate, or perhaps rather clay rock, from Ronneburg.

Clay slate, in rhomboidal fragments, from Ditterbach.

Thick clay slate, with a coarse-grained earthy fracture, from Upper Lusatia.

Green clay slate, with calcareous spar, from Shneeberg.

The same, with cinnabar, from Idra.

Clay slate, with yellow blend, from Transylvania.

From the Ganges.

Specimens of clay slate, collected on the river Ganges, and its vicinity, by Colonel Hardwick, on his journey to Siranagur.

Clay slate, from the rocks about Ghinouly.

The same, of a silky appearance, and seemingly much mingled with magnesia, from the rocks near Siranagur. It is of an ash grey colour, and finely undulated.

Greenish micaceous clay slate, from Coadwara.

Purple clay slate, veined with dull green, from the rock of Bedeyl.

Lilac-coloured clay slate, which alternates with laminated smectite, in the hills near Adwaanee. The strata are inclined 45°.

Brown clay slate, found in thick strata near Hurdwar.

Clay slate, in thin layers of different colours, from Bedeyl.

Purple clay slate, from high mountains near Siranagur.

Micaceous clay slate, of a bluish grey, from Ansore.

Clay slate bricia, intersected with quartz veins, in a cement of clay slate tufa, from Bedeyl.

Clay slate, intersected with quartz in all directions, from the same.

Clay slate, of a brownish red, and various other colours, from Ansore.

Brown clay slate, in bowlders, found in the bed of the Alecnundra, near Siranagur[*].

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[*] These specimens were presented by Colonel Hardwick to the author.

European.

To the European may be added,—

Micaceous clay slate, from Mont Blanc.

Clay slate, mingled with chlorite, from Mont Blanc.

Purple clay slate, with spots of quartz and mica, and thin layers of talcous schistus, from the same.

Soft grey clay slate, from the same.

Grey clay slate, sometimes spotted with decomposed pyrites, from the summit of Snowdon, where it rests in beds nearly horizontal, on arrects or uprights of schistose keralite.

A remarkable clay slate, of a yellowish brown, with long streaks, so as to have the appearance of oak board, with some knots of a deeper brown, and others white. It is mingled with a little quartz and mica. Sauss. § 1482.

STRUCTURE II. SECONDARY.

This either occurs uniform, or with impressions of vegetables, or sometimes of shells.

Aspect 1. Uniform. Thick slaty shale, from Derbyshire.

Shale, from numerous coal-mines.

Variety. Bituminous shale, from the same.

Aspect 2. With impressions. Shale, with the impression of the skeleton of a fish in a lighter colour, from Hessia.

Shale, with the impression of an ammonite, from Chamouni.

The same, with impressions of various vegetables, chiefly gigantic ferns, from various coal-mines.

Variety. Bituminous shale, with various impressions.

Black chalk.

Hone.

There are two substances often found in clay slate, and considered as of a kindred nature, but they never appear in the form of rocks. 1. Black chalk, so called because it is used in drawing, and which, according to Weigleb, contains 11 of carbon. 2. Hone, which is as proper and sonorous a name as novaculite, or whet-slate. Some clay slates and sand-stones form the coarser whet-stones, used by cutlers. The finest hones are said to be brought from Turkey, but they are also said to be found in the neighbourhood of Namur, in Flanders. Brochant says that it is also found in Bohemia, in Saxony (Seifensdorf, near Freyberg), in Siberia, in Stiria: lastly, at Lauenstein, in the Margraviate of Bareith, where it is wrought. It often seems to form the passage to indurated talc, and is sometimes covered with efflorescences of sulphate of magnesia, which has led to a belief that talc is one of its constituent parts; as Werner also suspects, from its unctuous feel, and being often of a greenish tint. It not unusually presents two layers; the upper of a pale greenish yellow, and the under of a blackish brown. The fracture is often scaly, which is seldom observed in other schistose substances; but that of Bareuth sometimes presents a slaty fracture, partly approaching to the conchoidal, and partly to the earthy. Hone seems nearly related to a highly indurated fullers' earth, and is said by some to decompose into tripoli*.

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* Saussure says, § 1594, that the common touch-stone is composed of little white grains of quartz and felspar, enveloped in ferruginous clay. The hard black nodules, which are found in slate, likewise afford very good touch-stones. The little hard grains form a kind of file, which seizes on the substance of the metal, while the black gluten displays the colour. And as acids do not affect the stone, the trace may easily be tried by the nitrous acid, or by the aqua regia.

MODE III. CLAY ROCK.

Characters.

Texture, of a fine earthy grain.

Hardness, marmoric, sometimes gypsic. Fracture, generally even, sometimes flatly conchoidal. If slaty, it approaches to clay slate. Fragments, amorphous, rather blunt.

Weight, granitose.

Lustre, dull. Opake.

This is the *thonstein* of Werner, which forms large rocks, and is the base of his clay porphyry, which will be described among the Argillaceous Intrites.

Eruptions of mud.

Macaluba.

In some countries, such as the Salses of Modena, in the Crimea, and near Girgenti in Sicily, hills and masses of indurated clay are produced by a singular cause, the eruption of what are called muddy volcanoes. Dolomieu has minutely described that of Macaluba, near Girgenti. A circular mountain, about 150 feet in height, is terminated by a plain somewhat convex, and about half a mile in circumference, which is surmounted by a great number of truncated cones, with little craters like funnels. The soil on which they rest is a grey dry floor, which covers a wide and immense gulf of mud.

There arises every instant, from the bottom of the funnels, a wet greyish clay, with a convex surface. This bladder, bursting with some noise, throws beyond the crater the clay, which runs like lava down the sides of the little hills; the intermission between the petty explosions being between two and three minutes. This hill has also more important fermentations, in which it affects to imitate a volcano; little earthquakes are perceivable at the distance of two or three miles, and there are serious eruptions, which sometimes elevate a sheaf of liquid clay to the height of 200 feet; the explosions being repeated three or four times in the twenty-four hours, and accompanied with a fetid sulphureous odour. This singular volcanello has been described by Strabo and Solinus; and the others present the same phenomena. Patrin says that the clay is of a greyish blue, and that Spallanzani has found in it the same elements as in basaltin. Dolomieu has also observed that the clay hills, which cover the surrounding country, are the produce of these eternal ejections mentioned by Solinus*.

When clay rock is strongly impregnated with iron it passes into jasper. The more common colours are grey and red, and it is sometimes spotted or striped. Mr. Jameson, in his Mineralogy, has promised a more particular account of *thonstein*; which he has not however accomplished in his Geognosy, where he only informs us that the Pentland hills, near Edinburgh, present examples. Dr. Babington, in his catalogue, mentions clay porphyry from the vicinity of Edinburgh; but gives no examples of the clay rock, which seems however to form a great part of that vast chain of mountains the Andes. In Chili entire mountains are composed of brown or black clay rock.

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* Dolomieu, Lipari, 158. Patrin Min. v. 249.

This substance frequently occurs in coal and other mines, where it receives a vast variety of provincial names, according to the fancy of the miners. In coal-mines it is commonly a shale, and alternates with beds of sand-stone, which also in such circumstances receives fanciful denominations*.

Clay rock, from Saxony.
The same, from the Andes.
The same, from Pentland hills.

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* What is called the clay-bed of the Leadhills, in Scotland, varies from the softness of tough clay, to the hardness of striking fire with steel; in the language of miners, *from mell and wedge to blasting:* and this too at a depth from forty to fifty fathoms.

Near Lesmahago, Lanarkshire, is a lead-mine in clay slate: the metal being in a vein of sulphate of barytes, five feet wide. G. L.

Saussure, § 1944, describes a kind of clay rock found among the pebbles of the two rivers called Emme, in Swisserland. This substance having hitherto little engaged the attention of mineralogists or geologists, all the accounts are very imperfect.

Porcelain clay.

Porcelain clay sometimes constitutes rocks; but it is merely a decomposed felspar, which may be found in the Domain entitled Decomposed Rocks. Potters' clay seems only to occur in separate strata; when of a greyish white, it is called pipe-clay. The clay of which the famous Egyptian vases have been formed for many thousand years, is, according to Roziere, of a marly nature, and is found near Coptos in the Thebaid. It approaches to the fawn colour, and is of a porous and light consistence. Porous vases which, by evaporation, impart great coolness to water, are also made in Spanish America, where the ladies are even fond of eating the fragments*. Molina, in his interesting account of Chili, has described several valuable clays, of which there is one which long retains a sweet smell.

Boles.

The Lemnian, Armenian, and other boles,

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* Da Costa, p. 20, says it is a bole useful in acidities, and as a dentifrice.

formerly celebrated as absorbents, and which are now supplanted by magnesia, are merely fine clays, which contain a small portion of magnesian earth. Hence they somewhat approach in their nature to the fullers' earth of Berkshire, and Ryegate in Surry*.

The earth called almagra, which is used to impart a red colour, and an unctuous feel, to Spanish snuff, is found at Almazaran, near Carthagena, in Spain, and seems a fine ferruginous clay, perhaps with a mixture of magnesia.

MODE IV. WACKEN.

Characters.

Texture, sometimes compact, sometimes vesicular. When the vesicles are filled with parasitic stones, it is called amygdalite; but as the base of the latter is more frequently a trap or basaltin, it has been classed after that substance.

Hardness, marmoric, sometimes gypsic. Fracture, commonly even, sometimes approaching the flat conchoidal. Fragments, amorphous, rather blunt.

Weight, granitose.

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* Bergman has put Hampshire, in which he is followed by all the foreign mineralogists; but there is no fullers' earth in Hampshire.

coarser sort at Ryegate, which contains crystals of barytes, is of a reddish brown, and is not used in commerce.

The analysis by Bergman bears that the fullers' earth comes from Hampshire, a mistake followed by a hundred mineralogic writers; and it was probably from Reading, in Berkshire, for in the vicinity of that town there are remarkable quarries, which lie under beds of sea sand, mingled with numerous shells of oysters. It is also found near Woburn, in Bedfordshire, and Ryegate, in Surry.

Da Costa informs us, that fullers' earth is dug at Wavendon, near Woburn, in Bedfordshire. For about six yards there are layers of reddish sand, then a thin stratum of sand-stone, then sand again for seven or eight yards; after which fullers' earth appears for about eight feet, followed by sand-stone and sand. At Ryegate and Nutfield, in Surry, the strata are similar; but at Detling, near Maidstone, in Kent, it underlies a sandy loam, mixed with a great variety of shells. It is prevented from being exported by a special act of parliament*.

Near Reading oyster-shells are found at the bottom of a high hill, a hundred feet below the surface. They lie on chalk, covered with sea sand, which still retains its brackish flavour. Above that is fullers' earth, nearly eleven feet in depth, and then chalk, and different kinds of clay; then a common sort of sand: and so on to the surface, which is gravel.

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* Nat. Hist. of Fossils, 1757, 4to. p. 69.

It does not effervesce with acids, nor is it diffusible in water, in which it does not froth like soap, as some have asserted. It is used in what is called the fulling of broad cloth, an operation which consists in extracting the grease.

Abroad, it has been found in Saxony, Alsace, and Sweden, always forming beds of more or less thickness. In England it commonly appears between beds of sand-stone.

The earth brought from Cimolus, which is described by Pliny as used in medicine and in bleaching, has again been discovered, by Mr. Hawkins. It is mingled with small particles of quartz; but this circumstance does not prove it to be a decomposed granite, as an accidental mixture of silex occurs in many substances.

Fullers' earth, from Reading, in Berkshire.

The same, with incumbent sea sand and oyster-shells.

The same, from Ryegate, in Surry.

The same, of a coarser kind and darker colour, with imbedded crystals of yellow barytes.

Mr. Sowerby has a large regular crystal of this kind, equal in beauty to a topaz.

Smectite, from Cimolus, one of the islands of the Grecian archipelago.

MODE VI. ICONITE.

This substance is only known by the little images brought from China, whence the name is imposed. From its unctuous appearance it was long imagined to belong to the Magnesian Domain, till Klaproth's analysis assigned it to the Argillaceous. It contains, silex, 62; argil, 24; lime, 1; water, 10; a combination which nearly corresponds with the smectite of Cimolus. The abundance of water seems, in this and some other substances, to impart an unctuous appearance; but the refinements in modern chemistry may perhaps discover something particular in the composition of this water*.

Bildstein. The Germans denominated this substance *bildstein*, that is, image-stone, which Klaproth has translated *agalmatolite*, while he might have used the far shorter term here adopted. It must also be premised, that sometimes the red or flesh-coloured stone, more rarely used for the same purposes by the Chinese, really belongs to the magnesian kind.

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* The analysis approaches that of chalcedony, which has also an unctuous appearance, perhaps from the admixture of argil.

Klaproth mentions two kinds of iconite, the transparent and the opake; the former unexpectedly presenting a third more argil, and only half the water of the latter.

STRUCTURE I. TRANSPARENT.

Klaproth describes this sort as being of an olive or asparagus green, verging through various tints to a greenish blue. The interior aspect is very glittering, and of a greasy lustre; the fracture scaly.

STRUCTURE II. OPAKE.

This, according to Klaproth, is reddish white, flesh red, and with variously-coloured veins; the fracture is less distinctly scaly; the lustre dull, opake, but somewhat translucent on the edges.

Werner has rightly added to the colours of the bildstein the greenish grey, of different degrees of intensity, the yellowish passing into yellowish grey mingled with green, and into pale yellowish brown. The greyish white seems to be one of the most common tints of this substance.

Yu-she.

Du Halde, in his description of China, mentions that the district of Tay-tong-fû, belonging to Shan-si, furnishes the most beautiful *Yu-she*, which that author, in the confused mineralogy of the time, calls a kind of white jasper. He adds, that it resembles agate, is transparent, and sometimes appears spotted.

Goez, who travelled to Tibet in 1602, in describing Yarkand, the capital of the kingdom of Kasgar, in Little Bucharia, mentions, that a commodity, particularly acceptable in China, was a kind of marble or jasper, found in Kasgar[*]. "The king of Katay buys it at a great price; and what he leaves, the merchants sell to others at exceeding great rates. Of it they make vessels, ornaments for garments, and girdles, with other toys, whereon they engrave leaves, flowers, and other figures. The Chinese call it *Tushe*[†]. There are two kinds; one more precious, like thick flints, which are found by diving in the river Kotan, not far from the City Royal: the other meaner sort is digged out of quarries, and sawed into slabs above two ells in breadth. The hill where they are dug, called Konsanghi Kasho, or the stony mountain, is twenty stages from the same city. This marble is so hard, that they must soften it with fire to get it out of the quarry. The king farms it every year to some merchant, who carries provisions for the workmen for that space of time."

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[*] Green's Voyages, iv. 645.

[†] In the original *Tusce,* a mistake, no doubt, for Yu-she, the word used by Du Halde. There seems great reason to infer, that the *pocula murhina* of the ancients were of this substance.

This precious substance, if we judge from its hardness, cannot be the present article; but is probably that beautiful jad (though perhaps future discoveries may impose a different name), which is brought from Tibet and China in the form of small basins, sword-handles, &c. It somewhat resembles chalcedony, but is far more ponderous. The chemical analysis and proper classification of this singular substance remain among the desiderata of mineralogy, though specimens be not uncommon in various great collections.

MODE VII. ARGILLACEOUS INTRITE.

The argillaceous intrites and glutenites are of prodigious extent and importance. The chief intrite, commonly called clay porphyry, as consisting of crystals of felspar in a base of clay, is sometimes a principal material in vast chains of mountains. The argillaceous glutenites, called rally diffused of this kind, may rather pretend to the latter denomination, as where the pebbles are large, they are commonly interspersed at considerable distances.

STRUCTURE I. LARGE-GRAINED ARGILLACEOUS GLUTENITE.

In arrects.

Valorsine.

The most remarkable rock of this kind is that described by Saussure, who discovered it unexpectedly in a vertical situation, in the Alps of Valorsine. In 1776, and afterwards in 1784, he visited the mountain of Balme, which gives source to the river Arve, and made the following curious observations, which chiefly contributed to lead to his system of *refoulements* or subversions, an idea which unhappily he does not explain at full length, but implying that the rocks now found vertical were formed in a horizontal position, and were afterwards elevated by some cause operating in a contrary direction from beneath or above[*].

"The base of this mountain is a genuine grey granite, with grains of a middling size, and of a structure nothing remarkable. But above these granites are found schistose rocks of quartz, mica, and felspar; an intermediate kind of rock between veined granite and common mica slate. Their beds run from north to south, as does the valley of Valorsine, and form an angle of 60 degrees with the horizon, leaning to the west, against the valley. These rocks are continued in the same situation for more than half an hour's walk; they are lost sight of under the verdure which covers a small plain, situated in the midst of woods, and which is called *le plan des Ceblancs.*

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[*] The French of the Swiss writers in general is impure, and sometimes requires a particular dictionary, as they *think* in Swiss or German.

"From thence, ascending obliquely on the south side, great blocks of grey schistus, or of a violet red, are found, sometimes even of a decided violet colour, which contain a great quantity of foreign pebbles, some angular, others rounded, and of different sizes, from a grain of sand to the size of the head. I was desirous of seeing these pudding-stones in their native place. I went straight up, to get to it; but there, how was I surprised to find their beds vertical!

"This surprise will easily be conceived, when it is considered that it is impossible that these pudding-stones could have been formed in this position.

"That particles of the greatest tenuity, suspended in a liquid, may be agglutinated among themselves, and form vertical beds, is what we easily conceive, and of which we have proof in the instances of alabaster, agates, and even in artificial crystallisations: but that a ready-formed stone, as large as the head, should stop in the middle of a vertical wall, and have waited there, till small particles of stone should come and surround it, cement it, and fix it in that place, is a supposition at once absurd and impossible. It must then be considered as a thing demonstrated, that these pudding-stones have been formed in a horizontal position, or nearly so, and elevated after their induration. What is the cause that has elevated them? It is what, as yet, we are ignorant of; but it is already one step, and that an important one, to have found, among the prodigious quantity of vertical beds which are met with in our Alps, some, which we are very certain have been formed in a horizontal position.

"Even the nature of the substance which envelopes the pebbles of these pudding-stones, renders this fact more curious, and more decisive. For if it was a misshaped and coarse paste, it might be thought that these pebbles, and the paste which cements them, were thrown pell-mell into some vertical crevices, where the liquid part hardened by drying. But on the contrary, the tissue of this paste is of admirable regularity and fineness; it is a schistus, whose elementary laminæ are extremely thin, mixed with mica, and perfectly parallel to the planes which divide the beds of the stone. Those beds themselves are very regular, well connected, and of different thickness, from half an inch to several feet. Those which are thin contain few, and sometimes no foreign pebbles; and some alternations are observed of thin beds without pebbles, and thick ones which contain them. The colour of the base of this schistus varies considerably; it is grey, greenish, most often violet, or reddish; some is also found marbled with these different colours. These beds are in a direction from north to south, exactly like those of granitoid rocks, which are under them; but the inclination of the schistus in much greater, its beds are often nearly vertical; and when they are not, they rise some degrees on the same side as the rocks I have just mentioned, that is, towards the west.

"The pebbles buried in this schistus are, as I have said, of different sizes, from a grain of sand to six or seven inches diameter; they all belong to that class of rocks which I call primitive; yet I have not observed massive granite; only laminar granite, laminar rocks, blended with quartz and mica; even fragments of pure quartz, but positively no schistus purely argillaceous, nor any lime-stone; nothing which effervesces with aquafortis, and even the paste which contains these stones does not. Their form differs; some are rounded, and have evidently lost their angles by friction; others have all their angles sharp; some even have that rhomboidal form that those kind of rocks so often affect. In those parts of the rock where these pebbles are imbedded in great quantities, the elements of the schistus have not had room to arrange themselves, and form parallel laminæ; but every where, where the stones leave between them sensible intervals, the laminæ reappear, and are constantly parallel, both with one another and with the planes which divide the beds.

"The mass of these schistose pudding-stones constitutes a thickness of near 100 fathoms in the mountain, reckoning from east to west across the beds; and I traced it in the direction of its length, for more than a league: it cannot be traced farther, because the beds hide themselves, and are buried under the earth.

"Above these pudding-stones, to the south, slate is found, of which the beds are rather less inclined, and the direction a little different; they tend some degrees more to the east, like those of Col de Balme, but they lean to the same side, as those among the beds of pudding-stones, which are not quite vertical: they lie towards the west.

"In continuing to ascend, thin beds of sandstone are found above the slates, which have the same situation and inclination with these last.

On these sand-stones are other slates; then thin layers of bluish calcareous rocks, mixed with mica; then the same stone with very little mica; and then again the same in thicker beds without any mixture of mica.

"Then the same succession recommences: first sand-stone, mixed with mica and quartz; on these lime-stones, in thin layers, mixed with mica and quartz; then the same, in thin layers, almost without any mica; and lastly the same, in thicker layers, entirely exempt from mica.

"Here the vegetable earth almost entirely covers the summits of the layers; only here and there, two or three feet above the grass-plats, eminences of calcareous layers, nearly vertical, are perceived. These eminences, arranged in parallel lines, as if they had been so placed by art, afford an appearance altogether singular.

"From thence to the highest limit of Col de Balme, you walk entirely on summits of slate, nearly vertical, which sometimes degenerate into laminar sand-stone, mixed with mica; and such is the nature of the peak, on which is placed the high stone; bearing on one side the arms of Savoy, and on the other those of Valais, with the date of 1738. These latter layers turn more directly from north to south, and approach nearer to the vertical position, than the slates, which are above the pudding-stones; but their inclination is always towards the west.

"The entire mass of this mountain, elevated 1181 fathoms above the sea, has then been raised by the same revolution, that is, this revolution has given a vertical position to the whole mass of these beds, originally formed in a horizontal one. For all these layers having very nearly the same position as those pudding-stones, they being imbedded in the midst of the mountain, and having undoubtedly undergone this change, it is impossible not to believe that the position of all the parts of the mountain has originally been the same, and that this position has experienced the same change by the same cause."*

Such is the account given by this great observer of the most remarkable argillaceous glutenite which has yet been discovered; and it is worthy observation, that this instance, among many others, shows the error of the division, proposed by some, of bricias and pudding-stones; for here both angular fragments and round pebbles are found in the same mass.

Bricia of Scotland.

A great part of the north of Scotland, and almost the whole of the Orkneys, consist of an argillaceous sand-stone, with interspersed masses of bricia, consisting of granite and other primitive rocks. But this bricia seems to be united by a siliceous cement: if the fragments be sometimes joined by the argillaceous sand-stone, it may be classed under this division.

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* Sauss. vol. iii. 138. 8vo.

Grauwack.

The substance called grauwack by the Germans sometimes contains large fragments of clay slate, and large pebbles of quartz; but as its grain in general is rather that of a sand-stone, it will be considered under the next structure. The German name is not only barbarous in itself, but implies grey wacken; while wacken is a rock essentially different. Mr. Kirwan says that it is the *grès-gris*, or grey sand-stone, of the French, a name very applicable; and it seems also to be the *grison* of some French topographers. The latter appellation might be adopted as at once expressive and sonorous; but as other important rocks have received appellations from the illustrious founders of mineralogy, the term Bergmanite may perhaps be preferable.

STRUCTURE II. SMALL-GRAINED ARGILLACEOUS GLUTENITE.

Grison, or Bergmanite.

The most celebrated rock of this denomination is the Grison, or Bergmanite, just mentioned, being composed of grains of sand, various in size, sometimes even kernels of quartz; which, with occasional bits of hard clay slate, and sometimes of schistose keralite, are imbedded in an argillaceous cement, of the nature of common grey clay slate. When the particles are very fine, it assumes the slaty structure, and forms the grauwack slate of the Germans. It is the chief of Werner's transitive rocks, nearly approaching to the primitive; while at the same time it sometimes contains shells, and other petrifactions of the secondary.

This important rock was formerly considered as being almost peculiar to the Hartz, where it contains the richest mines; but as the science has advanced, it has been observed in many other countries. The slaty grison, or Bergmanite, has been confounded with a clay slate; and we are obliged to Mr. Jameson for the following distinctions: 1. It is commonly of a bluish, ash, or smoke grey, and rarely presents the greenish or light yellowish grey colour of primitive clay slate. 2. Its lustre is sometimes glimmering from specks of mica, but it never shows the silky lustre of clay slate. 3. It never presents siderite nor garnets. 4. It alternates with massive grauwack. But is not the chief distinction its aspect of a sand-stone, which has led to the trivial French name of *grès-gris*, and the English *rubble-stone*, which may imply that it was formed of rubbed fragments, or of the rubbish of other rocks? The fracture is also different; and three specimens of various fineness, which I received from Daubuisson at Paris, could never be confounded with clay slate.

"This rock is uncommonly productive of metals, not only in beds but also in veins, which latter are frequently of great magnitude. Thus almost the whole of the mines in the Hartz are situated in greywack. These mines afford principally argentiferous lead-glance, which is usually accompanied with blend, fahl ore, black silver ore, and copper pyrites. A more particular examination discloses several distinct venigenous formations that traverse the mountains of the Hartz. The greywack of the Saxon Erzgebirge, of the Rhine at Rheinbreidenbach, Andernach, &c., of Leogang in Salzburg, is rich in ores, particularly those of lead and copper. At Voröspatak and Facebay, in Transylvania, the greywack is traversed by numerous small veins of gold.

"The whole of the important lead-glance formation of Leadhills and Wanlockhead is situated in greywack.

"It was for a long time supposed that this rock was peculiar to the Hartz, where it occurs in great quantity: later investigations however have shown, that it is widely and abundantly distributed. Besides the Hartz, it occurs also in the Electorate of Saxony, on the Rhine, as at Ehrenbreitstein and Oppenheim, Bohemia, Silesia, Moravia, Salzburg, Switzerland, Pyrenees, Transylvania, Tuscany, France, and Portugal; nearly all the mountains in Scotland, that lie to the north of the Frith of Forth, are principally composed of this rock: and many, if not the whole, of the mountains in Cumberland appear to be of the same nature."*

Argillaceous sand-stone.

Another remarkable rock, belonging to this division, is the argillaceous sand-stone, which composes the Orkneys, and part of the north of Scotland. It is commonly of a brown colour, and more or less indurated by iron, whence it sometimes decomposes in fantastic forms. The south-eastern part of the Mainland of Shetland also consists of this sand-stone, which has unexpectedly been found to be metalliferous. A copper-mine was opened near Sandlodge, the upper rock being sand-stone, while, at the depth of 150 feet, was found a rock of keralite, traversed by many veins of brown quartz. The copper was imbedded in an iron ore, in veins between the sand-stone and the keralite. "The iron ores here found are, 1. Dark-brown, fibrous, and mamellated hematites. 2. Columnar bog-iron ore. 3. Micaceous iron ore. 4. Iron ochre, of a brown colour. 5. Stalactitic iron ore, colour dark brown. 6. Earthy matter, much charged with iron, seemingly arising from the *debris* of other ores. The copper ores are, 1. Friable and amorphous carbonate of copper, colour rich green. 2. Beautiful carbonate of an emerald green, crystallised in capillary fibres of a silky lustre, diverging in radii from a centre; this species is found imbedded in iron ore. 3. Sulphuret of copper, disseminated through felspar in some places, and in others, in great masses, in iron ore. The rich carbonates were found near the bottom of the mine."[*]

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* Jameson, Geognosy 151. In his Dumfries, p. 92, he says the *craigs* near that town consist of fragments of *syenite* and grauwack, the bricia being cemented by ferruginous clay.

This sand-stone also often occurs in a schistose form, when it is called sand-stone flag.

Whet-stone, &c.

The Wernerians have confounded the sand-stones, as they have the porphyries, while they ought to be carefully distinguished according to the nature of the cement. The whet-stones and filtering-stones are often argillaceous glutenites, as is the important division *Cos* of Wallerius, Linnæus, and other writers in Latin. Some whet-stones are curiously spotted, commonly with dark specks on a light ground[†]. According to Wallerius, the filtering-stone from the Canary Islands, and New Spain, consists of angular particles of quartz, united without any cement; but the pure siliceous sand-stone seems the most uncommon.

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[*] Dr. Trail's Mineralogy of Shetland, in Neil's Tour, p. 170.

[†] Da Costa, 120, &c. mentions the whet-stone of Derbyshire as of a lax texture, easily pervaded by water, as most clays are. The grind-stone of Gateshead, Durham, also possesses this quality.

Gmelin, in the last edition of Linnæus, has included *Cos* among the *Lapides arenarii*, which he rightly arranges in three divisions, with a siliceous, calcareous, and argillaceous cement. Of the latter he particularises that of Fahlun, in Sweden, where it forms the bottom of the copper-mine; and that found in many countries, where it is used for slates. The sand-stone of Derbyshire is chiefly argillaceous, as is probably the flag-stone of Oxfordshire. To this class also generally belongs the sand-stone found in coal-mines, which sometimes bears vegetable impressions. Some sand-stones present layers of variegated colours; the cement being probably argillaceous, tinctured with iron in various proportions *.

Saussure mentions the following:

Argillaceous sand-stone, in vertical beds, or arrects, which he says cannot be the effect of a simple subsidence, but implies a "*refoulement en sens contraire*, which has broken and raised beds originally horizontal." § 1166.

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* Mr. Jameson says (Dumf. 166) that the cliffs of Hawthornden are of red sand-stone: argillaceous or siderous? The same question may be applied to the chain of mountains behind our settlements in Notasia, or New Holland, which have been found impassable. Voy. de Peron, Paris 1808, i. 393. From the sea to that chain the radical rock is siliceous sand-stone.

A fine argillaceous sand-stone, speckled with mica. § 1442.

The beautiful *pierre de Moravie* seems of this kind: it is white, with purple lines*.

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* Gallitzen, Recueil des Noms des Mineraux, Brunswick 1801, 4to. Born mentions a sand-stone of Siberia, containing nodules of malachite. In Thuringia a sand-stone is found which is worked as an ore of copper; and it also contains silver, cobalt, and lead. Brongn. ii. 224.

Mount Rosa.

DOMAIN IV.

TALCOUS.

◆

MAGNESIA.

THIS earth seems first to have been discovered, or at least sold as a remedy, by an ecclesiastic at Rome about the beginning of the eighteenth century. Under the name of *magnesia alba*, it was proposed as a universal medicine, while it could do little more than supply the place of the

Lemnian earth, and other boles. As Theophrastus, however, in describing the stone called *magnetes*, says it may be turned on a lathe, and has a silvery appearance, Dr. Kidd agrees with Hill, that the ancient Greeks called the load-stone *heraclea*, but the more modern *magnetes;* and Pliny's [illegible]ion of the stone brought from Mag[illegible]a Asia, seems to belong to a talcous substance*.

Hoffman, Black, and Bergman, contributed to establish the difference between magnesia and lime. It seems originally to have been prepared from nitre; but sea-water contains the sulphate of magnesia, a salt composed of this earth and sulphuric acid; and which is also found in many springs, particularly at Epsom, whence it was called Epsom salt.

Magnesian or talcous earth is infusible in the strongest heat. It does not form phosphorets, like the three other alkaline earths, lime, barytes, and strontia.

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* Kidd, i. 91. It is singular that the modern Italians have also a *calamita bianca,* or white magnet, which is described as fibrous, and probably belongs to the same description. Ferber, Italy 88, says it is a white hardened bolus, striated like asbestos.

In talc it sometimes amounts to one half of the composition; but in the other substances, such as steatites and serpentines, it is only from twenty to forty; but its power is so great as sensibly to alter the appearance and qualities of the stone. The chrysolite or peridot of the French, containing about one half magnesia, belongs to this division; and is remarkable as the only magnesian gem.

The deserts of Siberia are annually covered with efflorescences of Epsom salt, so as in the short summer to resemble snow. The talcous rocks in general present a discriminating character in their unctuous appearance; they have however, in some cases, been confounded with the argillaceous, which occasionally assume the softness and silky lustre of the magnesian. The presence of magnesia is often indicated by a green colour.

MODE I. TALC.

Distinctions.

Of this beautiful substance, considered as a rock, there are two principal structures: the COMMON talc, which occurs in translucent leaves, sometimes as large as four or five feet in diameter, and which chiefly comes from the Uralian mountains of Russia, whence it is called Muscovy talc; and what may be called MASSIVE talc, consisting of minute scales, irregularly agglomerated, as in the substance called the chalk of Briançon, which, from its farinaceous decomposition, and other circumstances, cannot justly be regarded as a soft steatite, but must belong, on the contrary, to this division. It must at the same time be remarked, that the deficiencies of all our mineralogic systems, concerning so common a substance as talc, are not a little surprising. The grave and profound Wallerius justly confines the appellation of talc to the two substances above mentioned; but the science has continued to suffer by the confusion of two very distinct branches, petralogy and lithology, every minute substance found in a vein, or parasitic, disturbing the attention from the grand features of nature. The magnesian

Common.

Massive.

rocks, in particular, have never been described with that attention which their curiosity and importance authorise.

STRUCTURE I. COMMON TALC.

Characters. Texture, finely foliated, and of a glassy appearance; level, undulated, or involved.

Hardness, cretic. Fracture, slaty. Fragments, amorphous, rather sharp, but the corners easily crumble into white powder.

Weight, pumicose.

Lustre, shining. Translucent, semi-transparent, sometimes transparent.

The colour is commonly a silvery grey, but often also light brown; and specimens of this colour are found, though very rarely, with beautiful metallic veins, or illinitions. It is also found of various beautiful tints of green, sometimes changeable, being reflected as it were through a white surface.

Sites. It abounds in the Uralian mountains; and it appears, from the accounts of Gmelin and Pallas, that it sometimes may be said to form whole mountains, while a mountain of quartz appears on one hand, and a mountain of felspar on the other, so as to present elements of granite on a vast scale. Fine talc is also found in the mountains of Tyrol, whence it was brought to Venice, and when exported from that mart assumed the name of Venetian talc. When calcined into an impalpable white powder, it was found a far more innocent paint for the ladies than bismuth, formerly used, but which is apt to become black, from the approach of sulphureous, and some other fumes, or even perfumes. An accident of this kind, operating hysterically, as not unusual with the sex, may have occasioned the invincible aversion from perfumes entertained by the Roman females. But as white is now rarely used, calcined talc is mixed with carmine, to form an elegant rouge; which is laid on with a bit of cotton wool, and rubbed off with as much ease as hair powder. Venetian talc.

Melina's able account of Chili affords the following information: Of Chili.

"Muscovy glass is there found in the greatest perfection, not only for its colour, but for the size of the pieces which may be obtained. It is generally used for glazing, and artificial flowers. The plates of this mineral, which are used for windows, and which are here much esteemed, because they are pliable, and less fragile than glass, are often a foot in length; and I am convinced they might be obtained two feet, if a little more care was taken in the quarrying. This substance is as white and transparent as the best glass; and it has a quality which seems peculiar to it, that of preventing passengers from seeing those within the apartments, while these perfectly discern objects without. A second kind of this glass is less esteemed, which, though found in plates of a foot square, is spotted with yellow, red, green, and blue; and consequently is not used as the former. It might be called *mica variegata*."*

In the Swiss Alps a beautiful talc is found, of a changeable green, on silvery white, with thin leaves forming contorted masses, adhering to a magnesian rock. Talc also occurs in leaves of various sizes, from half an inch to six or twelve inches, in granitic rocks, where it supplies the place of mica. When not larger than mica, it is here called micarel, genuine mica being ranked among the siderous substances. Mr. Kirwan has given the name of talcite to a parasitic substance, in the form of small scales, loose, or slightly coherent.

Chalk of Briançon.

The gradation of the involved or contorted talc of Swisserland, to the chalk of Briançon, or of Dauphiny, is sufficiently apparent. The latter is used by the French tailors in marking the shapes on broad cloth, whence the name of chalk has been improperly bestowed. The gold and silver mica of many writers seem rather to be talcous or micarel; as the large brown talc sometimes verges to a golden colour, and it is suspected that no iron is found in either.

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* Molina, Stor. Nat. del Chili, p. 77. The French translation is very inaccurate.

The Muscovy talc has been used instead of glass for windows and lanterns, especially on board of ships, where it is not subject to be broken by the firing of cannon*. It was formerly confounded with laminar selenite; and both were called *glacies Mariæ*, or the ice of the Virgin Mary; as the latter is still called by the labourers at Montmartre *pierre de Jesus*, because it served as a glass before little prints of the Saints.

Aspect 1. Large foliated talc. White, from the Uralian mountains.

Greenish, from Tyrol.

Brown, from the Uralian mountains.

The same, with metallic lines, red, green, and blue, perhaps from the vicinity of copper-mines.

Aspect 2. Undulated. Of various tints, from the same countries.

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* It is the *mica membranacea* of Wallerius, which he says was brought from Archangel.

Aspect 3. Involved or contorted. White, from St. Gothard.

Of a silvery white, and light green, from the same.

Aspect 4. Mingled. Foliated talc, in small plates, forming, with felspar and quartz, a very large-grained granite.

STRUCTURE II. MASSIVE.

Massive talc, from the Alps of Dauphiny, commonly called chalk of Briançon; as vulgar appellations are never precise, a soft steatite is sometimes sold under that name: but the French tailors are not to be so deceived, and the genuine *craie de Briançon* may be had from them, leaving on broad cloth a farinaceous illinition. It must however at the same time be observed, that when a soft steatite is mingled with micarel, the impression will be somewhat similar to that of the chalk of Dauphiny. Nay, micarel itself has been found to decompose into steatite*.

The rock of soft scaly steatite, of a sea-green colour, discovered by Saussure in the Roth-horn,

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* Gmelin, Linn. 69, describes the Creta Brianzonica as *minutissimè lamellosum*; the soft steatite *particulis impalpabilibus*.

§ 2157, appears to belong to this division. It is mingled with grains of white felspar, and calcareous particles, which effervesce with acids. It is so soft as to be almost friable, and splits into level horizontal layers: this curious rock reposes on serpentine, and is surmounted by a micaceous lime-slate, strongly impregnated with siderous earth.

Dr. Babington has the following varieties*:

"Composed of broad, shining, flexible folia, closely compacted, and of a greenish white colour (Venetian talc), from Zillerthal in the Tyrol.

"This, from being of a white colour when reduced to powder, and leaving a beautiful polish on the skin, has long been employed as a cosmetic. Mr. Hepfner found it to contain magnesia 44, silex 50, alumine 6.

"The same, on the surface of semi-transparent felspar, of a pale reddish white colour, and shining fracture, from the same place.

"A polished slab of the same, of a pale green colour, and intermixed with shining silvery laminæ, from Scotland.

"Of a slaty texture, and greenish white colour (schistose talc), from Bareuth.

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* Cat. St. Aubyn, 38.

" The same, of a duller colour, and somewhat more compacted, from Hungary.

" In thin undulating laminæ, of a dark greenish grey colour, from Fahlun, in Sweden.

" The same, more indurated, and of a shining yellowish grey colour, from Zillerthal in the Tyrol.

" The same, of a divergingly striated texture, and dark grey colour, from Scotland.

" Composed of small compacted scales (talcite) of a white colour and silvery lustre, enclosing prismatic crystals of green quartz, from Dauphiny."

Karsten, in his catalogue of Leske's museum, has the following:

" Perfectly *apple green*, mutably reflecting silvery white, talc, from the Venetian states.

" Talc, reflecting from the apple green, slightly into yellowish, from the same place.

" Massive talc, of coarse and small granular distinct concretions; and the same, indurated, which is mixed with a large quantity of emery, from Ochsenkopf, at Schwarzenburg, in the Erzgebirge.

" A fragment of a talc nodule, the fracture of which is very slaty, from Tyrol."

MODE II. TALCOUS SLATE.

Characters.

Texture, nearly resembling that of massive talc, but easily divides into undulated fragments, of a quarter or half an inch in thickness, the feel being extremely unctuous, as that of soft steatite or soap-rock.

Hardness, cretic. Fracture, foliated. Fragments, amorphous, blunt, and soft.

Weight, carbonose.

Lustre, glimmering. Faintly translucent on the edges.

The colour is changeable, greenish or reddish, mingled with silvery white. It is found in the Swiss Alps, in Scotland near Portsoy, and in many other primitive regions. Being of recent observation, it is little known in books of mineralogy. It may perhaps be the laminar steatite of Wallerius, which he describes as of a grey colour, and found at Norberg, Salberg, and Garpenberg in Sweden.

Talcous slates of Saussure.

To this Mode may also be referred the following rocks, described by Saussure:

" The asbestiform steatite rested on a stone, which Mr. Struve says had received from Werner the name of *chlorite slate.* But the specimens before me are evidently of a composite rock.

"We there see schistose parts of a greenish grey, sparkling, which have the form of small scales of chlorite; but these parts are very refractory, and do not yield the glass of chlorite. They do not form the tenth part of the mass of this rock, in which parts of real steatite, of a greenish white, predominate, soft, translucent, and perfectly characterised.

"We besides find in this stone parts crystallised in little straight plates, rhomboidal, nearly rectangular, of a greenish grey, extremely brilliant, almost of a metallic lustre, a little harder than steatite in mass, but with a grey streak. These plates lay on one another, and form in the stone glistening spots of an irregular form, three or four lines in diameter, and one or two in thickness. Viewed with a microscope, the separated plates appear transparent and colourless; but their reduplication renders them scarcely translucent in mass. Under the blow-pipe they show themselves very refractory; they become opake, and covered only on their edges with a dark and brilliant amel. I cannot consider them but as a species of *rayonnant*, *strahlstein*, of Werner, much like that of § 1437, though with some differences.

" As then this schistus results from the assemblage of different stones, all of the talcous class, I call it *composite magnesian schistus.*

" § 1917. The collection that Mr. Struve sent to me contains a stone, with a label, which signifies that Mr. Werner had named it an *indistinct variety of chlorite slate.* Perhaps in this instance, as in the former, Mr. Werner assigned the name from specimens different from what I received. In fact these are still farther removed from chlorite.

" The rock before me, and of which I possess two large pieces, is of a black inclining to green. Its fracture is laminar, with plates often undulated, very thin, separable into very fine flakes, the direction of which varies in different parts of the same piece. This fracture is indifferently bright, and of a lustre inclining to the unctuous, as well as its touch. It is translucent on its edges, to the thickness of half a line; the very fine laminæ appear white and colourless: but those which are thicker, when looked through, appear of a beautiful leek green.

" This stone is soft, and may be scratched even with the nail; the streak being of a whitish grey, but little brilliant. Moistened by the breath, it exhales a strong earthy smell. Its specific weight is 2,905.

"Exposed to the blow-pipe, this stone melts with difficulty into a greenish grey glass, semi-transparent, which forms a globule, of the tenth of a line at most.

"It has therefore no resemblance with chlorite, and, being obliged to give it a name, I have called it *laminar magnesian schistus.*

"We find enclosed in this stone some clusters of crystals of the *rayonnant*, or *strahlstein*, which I have described in the preceding paragraph; and some detached crystals of octahedral iron. It is found at Weysler Stoude, in the valley of Urseren."

MODE III. MICAREL SLATE.

Distinctions. This has commonly been confounded with mica slate, and has the same general appearance; the spangles having however sometimes more of the silver lustre, and in other examples more of the unctuous cast of talc, than is observable in mica slate, where the magnesia is strongly impregnated with iron. It has also the usual adjuncts of talc, and seldom contains garnet, or the other siderous substances, that are found in mica slate. In decomposition, it sometimes forms plates or illinitions of steatite between plates of quartz. It abounds in all the primitive countries, but has not yet been distinguished from mica slate.

Aspect 1. Micarel slate, from the bed of the Ganges, near Sirinagur.

The same, from the Alps.

The same, from Scotland.

Aspect 2. Dendritic, from Spain.

MODE IV. STEATITE.

This substance so much resembles fine soap, that in Cornwall, where it abounds, it is commonly called soap-rock.

Characters.

Texture, compact, finely granular, and unctuous.

Hardness, cretic. Fracture, sometimes uneven, sometimes conchoidal. Fragments, amorphous, blunt.

Weight, carbonose.

Lustre, dull, unctuous, sometimes glimmering, with particles of micarel. Translucent on the edges.

The most common colour is white, sometimes delicately streaked with red, so as perfectly to resemble marbled soap. It also occurs greyish, greenish, and more rarely yellowish, and is sometimes dendritic, or spotted*.

Klaproth has analysed the steatite of Cornwall, of which he gives the following account:

Of the Lizard.

"The steatites of Cornwall (*talcum smectis*, Linn.) occur at the Cape Lizard, in serpentine mountains, which it cuts through in small, perpendicular, or rake veins. The finest sort of it is white, with bluish or reddish spots, resembling marble. When fresh from the mine it is so soft that, like soap, it may be abraded with the knife. It is used in making porcelain. The working of these mines is carried on by the House of the porcelain-manufacture at Worcester, which pays £20. sterling for the ton of 20 cwt., because the bringing it out to the day is extremely uncertain and dangerous, the serpentine rock breaking in so frequently. There also occurs in these mines another sort of it, less fine, and having spots of iron ochre; as well as a third, brown-red variety, mingled with green. Not far from thence, at *Ruan minor*, also in serpentine, there is found both a grey-white and a light slate-blue soap-rock, or steatite, and also a whitish steatite, crossed by calcareous spar, which gives it a smooth shining fracture.

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* The dendritic occurs in Saxony, and near Kildrummy, Scotland.

"It was the first, finest sort of steatites, that was the subject of the following analysis."

The result is, silex 48, magnesia 20, argil 14, oxyd of iron 1, water 15*.

Da Costa has given more particular information concerning the soap-rock of Cornwall.

"The soap-earth, or steatites, is found in a sandy creek, not much above a mile to the north-west of the Lizard point: the sand is very smooth and pleasant, of a mixed colour, light and blue, and when the tide is out, affords many turning and winding passages betwixt the rocks, also blue, and the vast masses of cliff, which the violence of the sea has separated from their mother land, and from each other. There are also two grots, one called Kynas hole, into which those sandy walks lead; but in them nothing remarkable is to be found, not even marine plants, it being altogether too often washed by the tides on the surface of these rocks. There is sprinkled here and there a smooth, fat, and seemingly unctuous kind of incrustation, in colour and feeling much like to the natural appearance of bees'-wax, or tallow, and much of the same nature with the white part of the soapy rock; but whether it exudes from the crevices of the rocks, several of which have little chinks (filled with this heterogenous matter), capable of emitting what they contain, or whether this substance is first washed off by the sea from those veins, and is again returned by the force of the waves, till it incrusts the rocks, time and further inquiries only can determine."*

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* Anal. Ess. i. 462.

"Most of the stones within reach of the sea are covered with an adventitious and most beautiful enamel; red, white, green, yellow, in thin lucid scales, sometimes riding on one another in different crusts. In the eastern part of this cove, as the Cornish people call it, or creek, the substance of the rocks, and the sides of the cliff, are more gritty, and being soft, crumbling, and of a reddish colour, mixed with veins of white, like marble; and the purest, and most beautiful, lying in veins like metals. It is here more particularly called the soapy rock; as, by its unctuousness, smoothness, and variegations, it greatly resembles the finest kind of soap.

"The veins of steatites are of different breadths; some run under the sea, some to near the top of the cliff, and some through the cliff up into the country, and seem in their course to cross the tin loads.

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* Da Costa, 37.

"Nearer the Lizard than the soap rock is another cove called Pintrith, which affords a greyish impure steatites, spotted with black.

"The new soap rock, lately discovered, is at Gew Grez, or Grez cove, in the tenement of Kynas, in Mullion parish: it is about three miles from Mullion town, and about a mile from the old soap rock, or cove, which lies farther southward. The entrance into the creek or cove is very steep, craggy, and horrid: on the right hand (in descending into the creek) the hills are crested with naked rocks, or cairns, as the Cornish people call them: the sides have also many, but they are small. About half way down the cove, a very small current of water traverses it, in a very serpentine manner, and discharges itself near the load, or principal vein of the steatites. On the right hand, as you descend the cove, it grows more craggy and much narrower; and a few yards lower, on the same side, lies the main vein or load of steatites. The various sorts are all blended together in spots, sometimes in greater quantities in one place than in another. In the white and red veined steatites, pieces of a compact, hard, slightly pellucid, sparry substance, are frequently found:

the main vein, or load, is about eight feet over; it does not consist purely of the steatites, but also holds quantities of rubble, or fragments of a hard, smooth, dusky, greenish, and red coloured talcy-like fissile stone, called by the inhabitants a variegated killas. Some small pieces of white spar are also met with, but rarely. About two hundred paces higher, on the left hand, I found a soft and very greasy straw-coloured steatites: in the sides of the country, that is, of the solid strata which enclose the vein, and intermixed with it, lay a reddish brown steatites, but the straw-coloured kind was in the greatest quantity: further down, near the level of the sea, the steatites load has been more regularly traced, and makes a course of about fourteen inches wide between regular sides: the left hand side of the cove is quite perpendicular, and consists of a hard black stone, seemingly divided into strata by small horizontal fissures, placed at great distances from each other. The other sides of the cove are more open and rugged, the sea beats strongly into the creek, which at low water has a small sandy beach."*

Of this substance there are two very distinct structures; the soft, already mentioned, and the hard. To the last the following interesting observations of Patrin chiefly refer; and they are the more freely extracted, because his works, like those of Saussure, though of the greatest importance to the science, have never been translated, and remain new to the mere English reader.

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* Da Costa, 37.

Patrin's account.

"There is often so little difference between ollite and steatite, that Saussure, who was so well acquainted with rocks, sometimes uses these two denominations in speaking of the same substance; or, at least, he calls steatite the substance which forms the base or the paste of ollite. The greatest, or the only difference which, in fact, exists between them is, that steatite is a more simple and more homogenous compound, and that it is also more unctuous, than ollite.

Steatite and ollite.

"It may be said, that steatite is to the ollites what *cornéenne* is to porphyries. It is a paste which contains crystals, or, at least, distinct particles, of mica, talc, sometimes of asbestos or amianthus; as the base of porphyries contains crystals of felspar, schorl, and grains of quartz. Steatite is even observed, as that of the summit of Roth-horn, near Mount Rosa, which contains grains of felspar; and this mixture also forms ollite.

"A steatite is found in Corsica, which is solid, of an even tissue, of a uniform olive-green colour, semi-transparent and unctuous: it is what the Germans call nephritic stone, on account of its resemblance to the jad of the river of Amazons, which has that name by excellence. This steatite is, with a slight difference of colour, exactly like the lard-stone of China.

"Saussure gives the description of a steatite of St. Gothard, which he calls asbestiform steatite: it is very interesting, because it shows the transition of one stone to another.

"It is of a grey, approaching to yellow or green, and it much resembles asbestos, but its fibres are much larger, softer, and more unctuous. Its longitudinal fracture shows large fibres, parallel to one another, irregularly prismatic, as much as three inches long: their lustre middling, sometimes bright; but it is owing to a bed of talc, which covers the fibres of the stone.

"Its transverse fracture is uneven, splintery: translucent on its edges: soft, and scratches with the nail. The small fragments melt by the blow-pipe into a black globule.

"It is then evidently, Saussure says, a species intermediate between talc, steatite, and asbestos.

"Romè de l'Isle mentions a greenish steatite of Corsica, crystallised in hexagonal plates, placed horizontally; and which are only, he says, distinguishable from mica as they are duller, and are oily and unctuous.

"I have similar crystals, which are found inlaid in topazes and emeralds of Siberia; and as I perceive the insensible transitions from pure mica to this unctuous mica, I look upon this last as a simple modification, or perhaps the commencement of the decomposition of the real mica.

"Saussure has observed on Mount Cervin, near Mount Rosa, a steatite which he has called specular. It terminates the last rock before the snow. He has given it that name because its surface is as smooth as a mirror, and as polished as this species of rock admits. Its colour is a very dark bottle-green; its fracture irregularly schistose; it is soft, and is easily scratched with a grey streak*.

"Saussure has elsewhere seen, and particularly near the convent of Mount St. Bernard, a large rock of a quartzy nature, whose entire surface is polished so as one may see one's self in it, as in a looking-glass. He justly regards this phenomenon as an effect of crystallisation.

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* See Sauss. § 2258.

"I have found in the lead-mine yielding silver of Kadaïnsk, in Daouria, near the river Amur, a steatite of a very remarkable variety. Although of a tolerable firmness, it is so unctuous, that in drawing the finger along its surface, it gives it the same gloss as it would to a piece of soap. It is of a perfectly homogenous tissue, although composed of very distinct alternate layers, from half a line to a line in thickness, of which some are of a beautiful milk white, and the others of an ochre yellow. These layers, although contorted, are parallel among themselves; and as it generally presents segments of concentric circles, the stone has the appearance of petrified wood.

"I had brought away two specimens, and I wished to wash one of them; but it was scarcely wet before it broke into little fragments, the size of a pea, all the fractures of which were perfectly conchoidal, and the angles very sharp. The mark of the layers has almost entirely disappeared in these fragments, which have assumed a uniform tint, between white and yellow. The thinnest fragments are translucent on the edges."*

This stone must resemble the circular talc described and figured by Wallerius.

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* Patrin Min. i. 195.

The softer steatite chiefly occurs in veins in serpentine, and in nodules in basaltin* and Saussurite: but the harder forms rocky masses, else the substance could not have appeared with propriety in the present treatise. The rock of hard steatite, described by Saussure, may serve as an example: he discovered it on his journey between Nice and Genoa, on the sea-shore, of the height of 15 or 20 feet. The exterior surface is shining: here reddish, there of a silvery hue, and rather soft to the touch.

Rock of steatite.

"It splits in irregular fragments, rather approaching to the rhomboidal. Its fracture is schistose, irregular, and otherwise very like its exterior surface: it gives a grey streak; is soft, and rather heavy; odour earthy; easily melts into a grey glass, which sinks on the support; it has no effect on the magnet.

"The rock composed of this stone is divided by veins of spar and quartz; and this last contains, in places, pieces of green hornblende.

"Some parts of this rock are of a bright deep-brown violet colour. The fracture presents schistose laminæ, irregular, small, and often conchoidal; the streak is of a reddish grey; like the other, it is soft, rather heavy, and very fusible, but its glass is black, while that of the other is grey; it is doubtless a superabundance of iron which gives these pieces their red colour, and causes their glass to be black; but this iron is under the form of oxyd, or what was called calx; for neither does this stone affect the magnet.

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* Fine specimens of this kind are brought from the isle of Rachlin, on the north of Ireland, celebrated as the retreat of Robert I. king of Scotland from the English power.

"This rock is succeeded by another, smaller, and of the same nature, on which stands a little chapel, dedicated to St. Andrew, which has given it the name of *Scoglio di St. Andrea.*

"This rock stretches along the sea; it is afterwards covered by a granular serpentine, similar to that of La Garde, § 1342, which, like that, splits in small polyhedral fragments, irregular, the faces coloured by ferruginous iridescences, and which falls like it in decomposition. This same stone is still seen in the ascent beyond Peggi."*

STRUCTURE I. SOFT STEATITE.

White soap-rock, from Cornwall.

The same, mottled with red or blue, from the same country.

The same, rather harder, from Portsoy, in Scotland.

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* Sauss. § 1357.

The same, with elegant variegations of red.

The same, greenish, in serpentine.

White steatite, with black dendrites, from Saxony.

Karsten mentions a massive steatite, which is found in extensive strata at Thierschein; but he does not distinguish between the soft and the hard kinds*.

" Steatite, crystallised in hexahedral prisms of a middling size, terminated by six planes, the edges formed by the meeting of the lateral and acuminating planes, truncated, but in other respects circumstanced as usual, in massive steatite, from the same place." †

Soft steatite, called Spanish chalk, but probably from the Alps of Dauphiny.

Soft steatite, from New Caledonia, where the savages mix it with their food. This custom is also known to the savages on the Orinoco; nor is it unknown in the German country of Lusatia. The Arabs are said to use it in their baths instead of soap, and it is also used as fullers' earth.

Steatite, in basalt, from Skey, and other western isles of Scotland.

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* Leske, 131.

† Ibid.

STRUCTURE II. HARD STEATITE.

Distinctions.

Soft steatite may be scratched with the nail; but when the coherence is such that this substance does not yield to the knife of copper, or even sometimes of steel, it must assume the name of hard steatite; the hardness extending from the gypsic to the marmoric, and even to the basaltic. It must here be premised that the little Chinese idols, formerly supposed to be of indurated steatite, are now known by chemical analysis to belong entirely to the Argillaceous Domain; a proof, among many others, of the insufficiency of external characters, and that mineralogy can derive no certain light, except from the lamp of chemistry.

Aspect 1. Compact. Hard steatite, approaching to serpentine, of a dark green colour, with chlorite, from Silesia.

Of a pale green, with black lines, from the Alps of Dauphiny.

The early writers sometimes confound the hard steatite with ollite.

Aspect 2. Laminar. The plates are commonly curved, and occasionally have a fibrous texture. It is translucent on the edges, and sometimes entirely. Mr. Kirwan calls it foliated, or striated steatite; and says that it is generally found in independent amorphous masses, sometimes investing or intersecting serpentine.

"Leek green, inclining to olive green, curved foliated steatite, from Norway.*

"Mountain green, partially sprinkled with black, foliated steatite, from Zöbliz."†

MODE V. OLLITE.

Characters.

Texture, earthy, rather schistose.

Hardness, cretic or gypsic. Fracture, uneven, somewhat slaty. Fragments, amorphous, blunt, often laminar.

Weight, carbonose, sometimes granitose.

Lustre, dull, sometimes glimmering, unctuous. Opake; if translucent on the edges it approaches to hard steatite.

The colour is often greenish grey, or blackish green; sometimes yellowish, or reddish. It is often spotted, like a snake, whence the ophites of the ancients, which certainly belonged to this kind, and not to the green porphyries, as has hitherto been supposed by a long train of mineralogists, copying each other. It differs from serpentine, by the grain being finer and fatter; and is more easily cut with a knife.

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* Leske, 131.

† Ib.

That of Chiavenna has been analysed by Weigleb, who found, magnesia 38, silex 38, argil 6, iron 15. Who would suppose, after this analysis, that Werner should place this substance among the argillaceous, with an equal contempt for chemical principles, which can alone afford any solid foundation for the science, as when he places the corindon gems among the siliceous, though they do not contain one atom of silex! The paternal love of his own system must be violent indeed, when it leads to such contempt of every principle on which the science has been founded.

This substance has commonly been called *lapis ollaris*, which has been translated *pot-stone*, from the use to which it has been applied, even from remote antiquity, Pliny mentioning that the stone of the isle of Siphnus, in the Grecian Archipelago, and the greenish stone of Como, in Italy, were both used in his time to make vessels for cooking food. Wad, in his account of the Borgian museum, mentions several Egyptian monuments of ollite, chiefly small statues.

Ancient.

The varieties are:

Ollite, of a blackish green, with grass green spots.

Ollite, of a yellowish green.

Of an olive green, with larger and smaller veins of a greyish black, spots of a liver brown, and small specks of an Isabella yellow.

Of an olive green, with grass-green spots.

Semi-transparent, of an emerald green, with irregular oblong spots of an ochre yellow. This would rather seem to be a hard steatite.

Of a greenish grey, with a cast of blue.

Of a yellowish grey, verging on Isabella colour.

Of a foliated structure, resembling, as he adds, the laminar steatite of Karsten.

Two other relics are of a brownish black, and a greenish black; in a third, mingled with a few grass-green spots.

The learned author has added the following observations:

Thebaic stone.

" To this class, which affords so many Egyptian remains in the Borgian museum, belongs the Thebaic stone of the ancients, which constituted large portions of mountains, the quarries being mentioned by Theophrastus. Pliny has observed that it was black, or of a dark colour, and marked with golden spots *. He also observes that it yielded a juice, whence

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* xxxvi. 8, 22.

it must have been soft, and was used for mortars, as, from its natural benignity, it seemed peculiarly fitted for pounding medicines. If we compare these indications with any Egyptian stone, we shall find they agree with this only, the colour being frequently black or dark, and sometimes spotted with golden mica, of a soft nature, and used for mortars, one of the remains being of that description."

It has already been mentioned in the description of green porphyry, that the Theban ophite of Lucan, and the dark ophite of Pliny, were spotted ollites, which in fact bear far more resemblance to the skin of a snake than green porphyry, to which the appellation has been carelessly transferred.

Boot's ophite.

Boot, physician to the emperor Rodolph II. 1576—1612, published a treatise on precious stones, certainly very able and acute for that period, for he was the first who, in treating of the diamond (lib. ii. c. 1. p. 117. edit. 1636. 8vo.), remarked that it belongs to the inflammable substances; an idea also, upon quite different and original grounds, adopted by the great Newton. This author, after quoting Dioscorides and Pliny, observes that the ophite is a grey stone, found at Zoblitz, and used in making pots or vases, and the reputation of its medical qualities continued to his day. The ollites of Zoblitz in Saxony are still well known.

Laet, in his treatise on Gems, 1647, 8vo. p. 168, rather confuses the question, as usual with commentators, but quotes Gesner, who seems the fountain of the error, that ophite is a green marble, or porphyry, owing to his merely reading one sentence of Pliny, without adding the subsequent context. Laet says, that he received from Crusius a fragment upon which he had written, "A fragment of the cup of Edward IV. King of England, formed of the stone called ophites, useful against poison, the gift of H. Morgan, 1581." This fragment was of a dull green colour, very little translucent, sprinkled with crystalline spots of a bright green, and pretty conspicuous if held before the light. This may have been a serpentine, or ollite, with hexagonal spots of green mica, or steatite. The erroneous application of the term ophite by the greatest mineralogists, for more than a century, will excuse even a repeated confutation.

Ophite of Edward IV.

Sites.

The ollite of Como, which is still in use, is of a foliated texture, and greenish grey colour. That of Saxony, used for tea-caddies, milk-pots, and several other purposes, is of a greenish grey, with irregular veins and spots of black. The noble house of Inverary, the seat of the duke of first may possibly be the white ophite of Pliny*.

Ollite, in rude pots, &c. from the extreme northern regions of America.

The same, formed into the heads of calumets, or pipes of peace, from North America.

MODE VI. SERPENTINE.

Characters. Texture, small-grained, compact.

Hardness, marmoric. Fracture, rather uneven, sometimes scaly, sometimes flatly conchoidal. Fragments, amorphous, rather blunt.

Weight, granitose, sometimes siderose.

Lustre, dull, sometimes rather glimmering. Opake; often faintly translucent on the edges.

The colours of this noble rock are surprisingly rich and various. They are thus enumerated by Mr. Jameson:

"Its principal colour is green, of which it presents the following varieties: leek, oil, and olive green; from oil green it passes into mountain green, and greenish grey; from leek green

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[*] Saussure says, § 1724, that near Zumloch, on the river Egina, there is a quarry of ollite, the stone being composed of whitish translucent talc, grey mica, little pyrites of a golden yellow, sometimes iridescent, and a little lime.

it passes into greenish black; from greenish black it passes into blackish green; sometimes it occurs yellow, and rarely yellowish brown: further, red, of which it presents the following varieties; blood red, brownish red, peach-blossom red, and scarlet red.

"The peach-blossom, and scarlet red colour, are the rarest.

"The colour is seldom uniform; there are generally several colours together, and these are arranged in striped, dotted, and clouded delineations."

Primitive.

It is a primitive rock, and appears to be stratified, but, like granite, very indistinctly. It is an important geological observation, that some rocks, particularly the calcareous, assume the appearance of being stratified, by incipient decomposition, as Ramond remarked in the Pyrenees. But may not even this circumstance be considered as a proof of original stratification, merely rendered more apparent by the decay of the softer parts; as, if there were no original joints for the humidity to enter, the decomposition would only occasion irregular crevices?

Werner and his disciples have observed near connexions between the formations of trap or basaltin and serpentine. When the former contains an excess of magnesia, it becomes a remarkable *pierre de corne* of Saussure, here called Saussurite, in honour of that great observer.

Patrin is perhaps the only professed writer on mineralogy who has enlivened his subject by variety of illustration; and as his work will probably never appear in the English language, his descriptions, which often contain anecdotes derived from his own extensive travels, are given with the less hesitation.

Patrin's account.

"Serpentine owes its name to its colour; it is generally green, often spotted with white, yellowish, brown, and sometimes reddish marks, which gives it some resemblance to the skin of serpents. Its green colour is owing to iron, which is abundant in it, and but little oxyginated*.

"It is generally opake; but some of its parts are occasionally semi-transparent. Though not very hard, it receives a fine polish, which has an unctuous appearance, like jad.

"Serpentine is a primitive rock; the formation has been a little posterior to that of massive granite, for it is very rare to find them united. It has been contemporary with that of micaceous and calcareous schisti, with which it is sometimes seen confounded, whether in the same or in distinct beds, but which alternate, and are reciprocally overlaid, the one on the other.

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* This seems rather doubtful.

"Serpentine is rather more abundant in nature than traps and *cornéennes;* and much more so than porphyries.

"It is generally found in amorphous masses, like porphyries, and seldom in distinct beds. It forms chains of hills or mountains, but little elevated, at the foot of great granitic chains: it is very rare to find it in very lofty mountains, and still more rare to see it form beds (arrects) approaching a vertical position, a position so common to micaceous schisti.

Mount Rosa.

"In regard to the little elevation at which serpentine is generally found, there is an exception, perhaps unique and very remarkable, in Mount Rosa, where there are summits which surround the central part of that mountain, which are composed of serpentine, although their elevation is from 1500 to 1700 fathoms, and upwards; and what is also very remarkable, is, that the beds of this rock are there in a position most often horizontal. But even this position, and the presence of serpentine at this great elevation, are owing to the same cause, which I shall explain in treating of geology; for this mountain, become famous since the travels of Saussure to that region, and which is one of the most extraordinary existing, is also one of those which will throw the greatest light on the mystery of the formation of primitive mountains.

"Europe is that part of the terrestrial globe in which most serpentine is found; the whole front of the Alps, which looks towards Italy, offers it almost every where, although these mountains show but very little of it towards Swisserland.

"It extends throughout Italy, where it is called *gabbro*. One of the finest is that of the hills of Impruneta, near Florence: it contains a good deal of that green, semi-transparent, and satiny substance, which Saussure has called smaragdite, on account of its fine colour of emerald green.

"France has some mountains of serpentine, especially in Limousin.

"The finest serpentines of Spain are from Sierra-Nevada, two leagues from Grenada: they have a green base, filled with glistening plates, of a yellowish colour. Superb columns have been made from it, which decorate the churches and palaces of Madrid.

"It is almost entirely wanting in northern Asia, with the exception of the eastern part of the Ural mountains, which separate Siberia from Europe. There are some hills which, at great intervals, accompany their base, following their direction from north to south. There are even some detached branches, which appear near Tobolsk, which is not far from those mountains.

" But from thence to the river Amur, that is to say, in a space of about a thousand leagues, scarcely any vestiges are found, in the great chains of Altai, Sayannes, and in the mountains of Daouria.

" The serpentines most known are those of Sahlberg, in Sweden, and of Zeoblitz, in Saxony, from which vases are turned of every kind, which are spread over Europe*.

" The serpentine of Bareith is filled with garnets of an irregular form, generally of the size of a pea: they are sprinkled in an equal manner in the mass, and when the stone is polished it presents a very agreeable mixture of spots, of a fine red on a green base. Trinkets and other ornaments are made of it.

" Saussure has observed several serpentines, in rolled blocks, on the shores of the lake of Geneva: they are remarkable by their specific gravity, which is greater than that of all other serpentines. He saw some soft, and some hard.

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* It is commonly an ollite.

The softest is foliated, and its specific weight exceeds 3000, which is the weight of oriental jad. It is this softest variety which the best resists the action of fire.

"Some of the blocks found in the valley of Chamouni present a green serpentine, marbled with white, like the serpentine of Saxony; others, a green serpentine also, but mixed with shining plates of green talc, threads of asbestos, and of brilliant and golden amianthus, with laminar crystals in the form of flattened parallelopipeds. These crystals have neither the hardness of schorl, nor the characteristics of hornblende; they melt into a white amel, while hornblende always gives a black glass. The plates of green talc are infusible; and the serpentine which constitutes the base of the stone melts, in bubbling and emitting little sparks.

"These fragments proceed from some *hills*, or considerable masses, which have been destroyed by time. Saussure saw, near Chiavenna, in the country of the Grisons, entire mountains of serpentine and ollite, which were only heaps of incoherent blocks.

"The summit of the mountain of Garda, near Genoa, is composed of a serpentine, which Saussure has called granular: it is of a deep grey green, with unequal fracture, dull, earthy, affording an argillaceous smell, and melting under the blow-pipe into a black glass. Its exterior is covered with a coat of rust.

"The observation of the characters of this rock is important, as it shows the transition of serpentines to *cornéennes*. It is absolutely midway between these two sorts of rocks.

"The beds of this serpentine alternate in the mountain with beds of calcareous, quartzy, and micaceous schistus; and with beds of primitive slate.

Roth Horn.

"The mountain called Roth Horn, or Red Horn, and which faces Mount Rosa, towards Italy, is elevated 1506 fathoms: it is composed of compact serpentine, divided into irregular masses of an immense size. The surface of this serpentine becomes red by the action of the atmosphere, which oxyginates the iron it contains to the highest degree. It is this colour, and the elongated form of this mountain, which have procured it the name of the Red Horn.

"This serpentine is covered by a steatite, of a sea-green colour, mixed with carbonate of lime, and grains of felspar. On this steatite beds of calcareous micaceous schistus repose, in which the mica contained is more than one half. These schisti are again covered by serpentine: all the beds are nearly horizontal, a little raised towards Mount Rosa. Geologists will perceive the importance of this observation.

Mount Cervin.

"Mount Cervin, another mountain near Mount Rosa, is an inaccessible obelisk, of a triangular form, which is elevated to the prodigious height of 2309 fathoms above the sea, according to the trigonometrical measurement, taken with the greatest exactness, by Saussure. It is composed of three distinct masses, piled the one on the other.

"That which forms the summit is of a yellow Isabella colour. It is composed of serpentine, mixed with micaceous schistus, calcareous, and quartzy. Saussure has thus judged of its construction from other neighbouring summits, which he has visited, and which present exactly the same colour.

"The mass which is under this is of a grey colour, and formed of gneiss and quartzy micaceous schistus. Saussure saw some of its fragments.

"The third exactly resembles the first; and Saussure found that it is also of serpentine, alternating with calcareous micaceous schistus.

"The base of the pyramid is of serpentine, but of a confused structure.

"I repeat, that mountains of serpentine are seldom of a great elevation; and that those about Mount Rosa are owing to a peculiar and local circumstance.

Magnetic hill.

"One of the most remarkable hills of serpentine, on account of the phenomena which it presents, is that observed by Humboldt, in 1793, in the chain of mountains which separates the margraviate of Bareith from the Upper Palatinate.

"This hill is only elevated fifty fathoms above the neighbouring plains: it extends in length from east to west, its skirts consequently are to the north and south.

"The rocks which crown its summit are of a very pure serpentine, which, by its colour and foliated fracture, approaches schistose chlorite. It is divided into tolerably distinct beds, and reposes on a veined granite, mixed with hornblende.

"Humboldt having brought his compass near these rocks of serpentine, saw with surprise, that the north pole flew round quickly to the south. He farther observed, that the rocks of the north declivity, and those of the southern, have their poles directly contrary. In the former are only found south poles, and in the latter north poles. The eastern and western extremities of the hill are in a state of indifference, and do not manifest any action on the magnetic needle, though otherwise the rock affords the same appearance.

"In the magnetic parts of this hill certain rocks are also observed, which have no action, by the side of similar rocks, which have a very strong one. Some affect the needle at the distance of 22 feet.

"This mountain not only exerts its action on the magnetic needle in its whole mass, like some other mountains, but it is manifest in even very small pieces. Humboldt has observed, that fragments, scarcely visible, are briskly moved, upon presenting to them, one after the other, the poles of the weakest magnet: and it is remarkable, that a substance possessing such a decided polarity, has not the least attraction on iron not magnetised.

"Humboldt convinced himself that this serpentine does not contain an atom of magnetic iron; all which it contains, and which colours it, is in the state of oxyd. It is for naturalists to explain the cause of so remarkable a phenomenon.

"The specific gravity of this serpentine is much less than that of others; it only extends from 1900 to 2000, while the ordinary weight of this rock is 2700, and even reaches, as Saussure has observed, to 3000, in certain varieties which he found in the vicinity of the lake of Geneva.

"M. Chenevix, the chemist, who has employed himself in a succession of analyses of magnesian rocks, found that serpentine and ollite are composed of the same elements; and that, according to a medial sum of many analyses, they contain, silex 28, argil 23, magnesia 34, oxyd of iron 4, water 11."[*]

Name.

The name serpentine seems to have been derived from the Italians, who however applied it indifferently to several substances; as black porphyry was called *serpentino nero*, and the green porphyry *serpentino antico*[†]. The name, which was vague at first, was afterwards confined to this magnesian rock, to which it is most strictly applicable, from the variegation and unctuous appearance of the colours.

Italian.

Ferber has minutely described several of the Italian serpentines, particularly that of Impruneta, near Florence. The colours are white, red, black, yellow, and green; sometimes uniform, sometimes intermingled. It is often intersected by small veins of asbestos, and sprinkled with an unctuous micarel, of a greenish silvery hue, of a square form, and not hexagonal, like mica. There are also perpendicular veins, from six to twelve inches in breadth, containing the following substances: 1. Farinaceous steatite, or soap earth, white and green. 2. Chalk of Briançon. 3. Fibrous steatite, passing to asbestos. 4. Asbestos. 5. White and green amianthus. As he wrote in 1772, in the mere dawn of genuine mineralogy, his names are modified by his descriptions.

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[*] Patrin Min. i. 177.

[†] Wall. i. 432. It is singular that this truly learned author should have followed the common error concerning the ophites of Pliny.

Useful in the arts.

As serpentine, like ollite, resists fire, it would be found of far more utility in domestic and public monuments than marble; yet its use has been unaccountably neglected, both in ancient and modern times. The beautiful serpentines of Portsoy, the singular white-veined marbles of Durness, and the most elegant of all the marbles, that of Tirey, with the fine green serpentine marble of Anglesea, might supply the British empire with decorations far exceeding the fashionable imports from Italy, the insipid marbles of Carrara and Sienna, especially at a period when we should only enrich our enemies.

Nephritic stone.

Serpentine, like the other magnesian rocks, impressed the ancients not irrationally with an idea of medical qualities. Internally they would act as absorbents; but the nephritic stone was supposed, when only worn, to cure diseases of the reins, or the lumbago*. This nephritic stone is often found in flat pebbles on the shores of the sacred island Hyona, among the Hebudes of Scotland. It approaches to what is called jad, the *giada* of the Italians, and is also found in the island itself, adjacent to fine white marble. As jad however has never been yet observed to constitute a rock, but, according to the imperfect observations, has only been found in rivers in schistose fragments, whence it would seem only to form thin layers, it has not been admitted into the present work. It must also be observed, that the analyses hitherto given of this substance are not satisfactory. The jad, which forms the base of the composite rock called the Corsican green, has been pronounced by Werner to be a felsite, or compact felspar; and if the analysis of the younger Saussure be trusted, it contains no magnesia. It may seem to be nearly the same substance with the iconite of the Chinese, only in a far higher state of induration. This substance has also, by some writers, been called *lemanite*, from the *Lacus Lemanus*, or Leman Lake, now called the Lake

Jad.

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* According to others, the stone, or gravel; in which sense it is used by modern physicians. See Johnson.

of Geneva, upon whose shores it was found by Saussure.

Werner and his disciples have continued the ancient name of nephrite to jad, which they class among the magnesian rocks; and they divide it into two sub-species; the oriental, which is brought from China and the East*, and what they call *beilstein*, or axe-stone, because it is brought in the form of axes from South America, whence it might strictly be called occidental. It is to be regretted that no able chemist, no Klaproth nor Vauquelin, has analysed the various kinds of jad, though a stone of celebrated beauty and utility; and it remains uncertain, whether it ought to be referred to the magnesian, the argillaceous, or whether it may not even be an unctuous keralite, resembling unctuous quartz. It may perhaps even be of various kinds and compositions, afterwards to be distinguished by new appellations. Recent French writers have called it *felspath compact jadien*†, which, they add, is the jad of the lapidaries, and the nephrite of the Germans; only different from other compact felspar by its tenacity, weight, and unctuous appearance, while it melts under the blow-pipe like other felspars. The able and ingenious Haüy has added the lemanite, or white jad, as an appendix to felspar, under the name of *felspath tenace;* while he ranks jad, the nephrite of Werner, among the substances whose characters are not sufficiently known to find a place in the system. He regards the axe-stone as totally different from the oriental jad, of which he gives two analyses, one by the younger Saussure, who found iron, manganese, soda, pot-ash, &c. &c. and has acquired little reputation as a chemist. Karsten, in his tables of mineralogy, Berlin 1808, has given another, by Kastner, which is probably authentic, and deserves repetition; silex 50, magnesia 31, argil 10, water 3, oxyd of iron 5, with a tint of chrome.

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* Wad, p. 23, mentions different monuments of nephrite, among which one of a leek green, which, he adds, is *giada*, and is marked with Persepolitan characters. Roziere brought from Egypt a fragment of red granite, marked with the same letters, from a monument which, if I remember right, he discovered in the Desert of Suez.

† Brard, 169.

Mineralogists having in general supposed that jad or nephrite occurs in veins or layers in serpentine rocks, it was proper some account should be given of so remarkable a substance. For the same reason, it may be proper here to mention asbestos and amianthus, almost constant in the midst of serpentine, but which cannot be regarded as forming rocks. The late ingenious Dr. Walker,

Asbestos.
Amianthus.

professor of mineralogy in the University of Edinburgh, who repeatedly visited the Western Isles of Scotland, is said to have asserted, that the little isle of Bernera, which terminates the exterior chain of the Hebudes, is composed of amianthus, or, as he more probably intended, a mixture of asbestos and amianthus. Lord Seaforth, the excellent proprietor of these remote regions, and himself a mineralogist, when consulted by the author, answered, that so singular a circumstance was unknown to him, though it could scarcely have escaped his information. The finest amianthus occurs in Corsica, forming beautiful white silky threads, of two feet or more in length; and it is so abundant, that Dolomieu used it instead of flax to pack his minerals. There is also a mountain in the Uralian chain which is called the Silky Mountain, as in the fissures of a Saussurite or magnesian basaltin there is found an amianthus, which at first appears compact and hard, but when exposed to the air for some months, it swells, and becomes a fine down, as flexible as cotton*. But even this can scarcely be said to form a constituent part of the mountain, and amianthus on a smaller scale is frequent in rocks of this description; so that it must continue to be regarded as a parasitic substance: and if even a rock or hill consisting solely of asbestos and amianthus were discovered, it must be classed among the anomalous, as being contrary to the usual course of nature.

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* Patrin, i. 216.

Having thus discussed the chief parasitic substances which are found in serpentine, it is proper to return to the immediate consideration of that celebrated rock.

Noble serpentine.

Werner and his disciples divide it into two of their barbarous *sub-species*, under the epithets Common and Noble; the latter being transparent, and chiefly found in Silesia. It is generally of a dark leek green, and of an unctuous visage. Mr. Jameson says that in Italy it is called nephrite, with which it might perhaps be classed. But when Brochant supposes that the *verde antico*, and other green marbles well known in Italy, belong to the noble serpentine, he forgets that they are all opake, while the latter is translucent. When he quotes Estner, who confounds the *verde antico* and ophite with green porphyry, the confusion is infinite; for the *verde antico* is a marble, which will presently be described; and the ophites, as already shown, is a mere error, echoed by mineralogists for a century and a half, while the ophites of Pliny is an ollite. The noble serpentine of Werner, which is found in small masses or disseminated, seems rather to belong to lithology or gemmology.

STRUCTURE I. ENTIRE.

Black serpentine, from Egypt.

Brownish serpentine, from the same. These are small statues, described by Wad.

Serpentine, with white spots, from Cecina, near Volterra, Tuscany.

Black, from Monte Ferrato-di-Prato, call *Nero-di-Prato.*

Green, from the same, *Verde-di-Prato.*

Gabbro, or serpentine of various colours, from Impruneta, seven miles south from Florence.

Green serpentine, with yellow spots, from the Sierra Nevada, in Spain.

Serpentine, shaded with various tints of green, from the Pyrenees*.

Deep green magnetic serpentine, from Bareuth.

Green serpentine, marbled with white, from the Vale of Chamouni.

Serpentines, from Corsica and Italy.

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* The erroneous ophite of Palassou, whose work on the Pyrenees has great merit. See his prolix dissertation on this pretended ophite, Journ. des Mines, v. 31. He is however nearer the truth than Gesner, and his successors, who supposed ophite to be green porphyry.

Brown serpentine, spotted with red, from the Lizard point.

Dark green serpentine, from the same: perhaps the name of the cape is derived from the colour.

Serpentine, of various colours, from Portsoy.

Yellowish serpentine, from Zoblitz, in Saxony.

Black serpentine, spotted with red, from the same.

Green serpentine, in pebbles, from the Lake of Geneva.

Granular serpentine, from the Alps.

Serpentine, from the mountain of Cervin.

STRUCTURE II. MINGLED.

With mica, from the Lizard point, &c.

With veins of steatite, from Cornwall, Portsoy.

With asbestos, from the same.

With amianthus, from Zoblitz.

With foliated steatite, amianthus, and garnets, from the same.

With garnets, from Bohemia.

With asbestos and calcareous spar, from Prato.

With spangles of satiny diallage, the smaragdite of Saussure, from Impruneta.

With metallic diallage, from Saxony.

With the same and epidote, from Queyras, near Briançon.

Saussure presents some uncommon examples:

Serpentine, with spots approaching to crystallisation: may not this be the stone mentioned by Pliny as gemmose? § 107.

Laminar serpentine, of a yellowish grey, with striated surfaces, and translucent on the edges. § 2253.

He also describes, § 1434, another granular serpentine, with an earthy fracture.

Mount Cervin rises to a prodigious height, under the form of a triangular obelisk of bare rock, which seems hewn with a chisel: the appearance is alike singular and magnificent. Saussure, § 2220, gives a curious account of this surprising mountain of serpentine.

MODE VII. SAUSSURITE.

Characters. Texture, fine-grained, compact.

Hardness, basaltic. Fracture, generally even and earthy, sometimes scaly. Fragments, amorphous, rather blunt.

Weight, granitose.

Lustre, dull, sometimes rather glimmering, from particles of siderite. Opake.

Colour, black or dark grey, sometimes faintly verging towards the green, from an excess of magnesia.

This stone may be regarded as intermediate between basaltin and serpentine, and might be called magnesian basaltin; but as it is the most remarkable *pierre de corne* of Saussure, it has been thought proper to give the name of that great observer to this important rock.

Cornéenne.

The *pierre de corne*, or *cornéenne*, is a vague appellation, still retained by the French mineralogists. It sometimes implies a trap, sometimes a wacken, sometimes an earthy siderite; and sometimes more appropriately the present rock. Saussure has observed, § 1225, that when the *cornéenne* appears crystallised, it assumes the name of hornblende. He has given, § 725, an analysis of his *pierre de corne*, and observes, that the chief difference between it and basalt is the mixture of magnesia. In Kennedy's accurate analysis of basalt there is no trace of magnesia; but in the Saussurite there ought to be more than 6 in the 100. The decomposition of the iron often forms a kind of bark around this stone, whence it has been called by some authors *pierre-à-ecorce*.

Dolomieu, in his celebrated memoir on felsite and trap, which precedes his distribution of volcanic products, observes, that the cavities in trap are commonly filled with calcareous spar; while those of his *roche-de-corne*, or Saussurite, besides calcareous spar, often present a green steatite extremely ferruginous *. This feature, with the occurrence of amianthus, and other modes of talc, confirms the magnesian propensity of this rock; and as these green nodules are also frequent in amygdalite, it is to be suspected that the latter, to the base of which various denominations have been assigned, may, when duly analysed, be found to belong to this division.

With steatite.

Dolomieu also considers the chlorite slate of Werner, which often presents octahedral crystals of iron, as intermediate, between the *roche de corne* and the talcs; while the former graduates from trap to serpentine.

" In Tuscany there are frequent examples of these passages of *roche de corne* to serpentine. At Pietra Mala, on the ridge of the Apennines, to the right of the road from Bologna to Florence, there is a mountain which presents all the kinds of gradations between serpentine and *roche de corne*, and the passage of the earthy grain of this to the scaly texture of hornblende, or *corneus spathosus*. This *roche de corne*, of a black base, marked with white and green spots, has been taken for a lava by many naturalists, among others by Mr. Ferber."*

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* Journal de Physique, 1794, p. 258.

That the *cornéenne* is a term which ought to be dismissed from mineralogy, will sufficiently appear from the following description, by Brongniart, a very industrious and exact mineralogist.

"*Cornéenne* † is a rock very difficult to determine, and still more difficult to confine to precise limits. On one side it approaches very near to wacken, and on the other to argillaceous schistus: it has besides numerous relations with basalt, and even with *amphibole*, or hornblende.

"This rock is generally compact and solid; its fracture is dull, rather even, but irregular; it yields by breathing on it a very sensible argillaceous odour; it is generally difficult to break, causing the hammer to rebound, and presenting a kind of tenacity, which throws it at a distance from wacken, and approaches basalt. It often possesses sufficient tenacity not to be scratched by the copper knife, which, on the contrary, leaves its mark. It is even difficult sometimes to be scratched with iron.

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* Journal de Physique, 1794, p. 258.

"† *Corneus*. Wall. This genus contains the greater part of our *amphibole hornblendes*. *Cornéenne* rock, Haüy; omitting the varieties 2, 3, and 4—vulgarly *pierre de corne*.

"This species must not be confounded with the *hornstein* of the German mineralogists: it has been seen that this was a silex. *Cornéenne* must also be distinguished from the *roche de corne* of Saussure, which seems to be a trap rock, in the acceptation that we give to that word, according to Mr. Werner."

" *Cornéenne* is easily melted into a black bright amel, and this character distinguishes it from schistus, when it possesses the texture of it, and from schistose jasper, when it approaches it by its hardness: it almost always acts upon the magnetic needle.

" Most mineralogists look upon this rock as an intimate and invisible mixture of amphibole* and clay.

" We shall establish the following varieties in this species:

" 1. Compact *Cornéenne.* It is solid, compact, difficult to break; its fracture is uneven, passing to the conchoidal.

" I will give, as an example of this variety, the brown paste, approaching to the violet, of the amygdaloids of Drac. Dolomieu considered it as a *cornéenne* well characterised. The paste of the amygdaloids of Derbyshire, called toadstone, should be equally placed with it, and that of the agates of Oberstein, &c.

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* An absurd name for hornblende or siderite, signifying forsooth *ambiguous*, while there is no substance less ambiguous. P.

"2. Trap *Cornéenne*[*]. This variety is hard; it wears iron, but does not sparkle; it is compact; its grain is consequently fine, close, and absolutely dull. This is what distinguishes trap from basalt; the latter always showing in its fracture a grain rather crystalline. It breaks in parallelopipeds: its fracture is sometimes conchoidal. Its most general colour is black, but there is some, bluish, greenish, and reddish. (Wall.)

"The trap here mentioned is an homogenous rock. It is easily distinguished by its characters from the trapose rocks.

"This rock is very common in several parts of Sweden.

"3. Lydian *Cornéenne*[†]. This *cornéenne* is black, dull, compact; it is softer than the trap, or *cornéenne*, and has not the parallelopided fracture: it is, on the contrary, perfectly compact, and sometimes rather schistose: it is scratched not only by iron, but also by copper, when the angle or edge of a piece of copper is applied; but when this rock is rubbed with the flat or

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"[*] *Corneus trapezius.* Wall. *Trap* is a Swedish word, which means stairs. This name has been given to this *cornéenne*, because the mountains which it forms present a kind of steps or seats in their declivities." (Wall.)

"[†] *Corneus trapezius. Lapis Lydius.*" (Wall.)

rounded part of a copper instrument, it receives the mark of the metal. It is by these characters that it is distinguished from the blackest and most compact argillaceous schisti; they being always scratched by copper, and never receiving any mark from it, however applied; besides, schisti do not melt like *cornéenne*.

"It is on the property, which the Lydian *cornéenne* possesses, of receiving the mark of certain metals, that the use that is made of this stone, to judge by sight of the quality of gold, is founded. It is vulgarly called touch-stone*. It has also the name of Lydian, because the ancients gave that name to touch-stone; but it no longer comes from Lydia. Those at present used come from Bohemia, Saxony, and Silesia. I dare not however affirm that the touch-stones of those countries are all related to this variety of *cornéenne*. It is even probable that the greater part among them are basalts.

"The Lydian *cornéenne*, of which we are here treating, is that used as a touch-stone among

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"* Touch-stones, and the manner of using them, will be spoken of more in detail in treating of the uses of gold. It is probable that different kinds of stones are used as touch-stones, schistus, schistose jaspers, and perhaps even basalts. Wallerius thought he distinguished three kinds of touch-stones, which he referred to three kinds of rocks, basalt, schistus, and *cornéenne*."

the goldsmiths and assayers of Paris. I have seen no other sort among them. It is so much the better, as it is blacker, and more compact. It is certainly, properly speaking, neither a basalt nor a schistose jasper. It is said to come from Germany, by the way of Nuremberg: but those who sell them know nothing more of it.

"*Cornéenne* belongs either to primitive or transitive earths. It never contains organised fossile bodies. Sometimes it forms thick beds, sometimes it presents itself in masses, in which the stratification is not perceptible. It constitutes in this instance the base of certain amygdaloids, or glandular rocks."*

Brochant is equally perplexed. The *cornéenne*, he says, is sometimes siliceous schistus, sometimes Lydian stone, sometimes the clay-slate of Werner, hornblende slate, wacken, trap. An appellation so vague ought to be finally dismissed. The other *pierres de corne* of the French will be found in their proper divisions; but as that analysed by Saussure himself contained magnesia, which rarely occurs in the stones above mentioned, it is proper to confine his illustrious name to the present division, which has scarcely attracted the notice of mineralogists. Mr. Kirwan has indeed observed, that serpentine is sometimes intimately mixed with hornblende, or trap, in which case it is black. It may in that case be regarded as a transition from serpentine to Saussurite; and the connection between trap and serpentine has been already observed by Werner.

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* Brongniart, i. 550.

Saussurite, in rolled pebbles, from the lake of Geneva.

The same, from the Alps.

Saussurite, with nodules of steatite, from the western isles of Scotland.

With veins of amianthus, from the Pyrenees.

This substance is common in Saussurite, and evinces its magnesian nature.

MODE VIII. GREEN GRANITEL.

A genuine green granite, found among the ancient monuments of Egypt, has already been described in the account of that rock; but that beautiful substance is so extremely rare, that it cannot interfere with the present object. The Egyptian is composed of quartz, mica, and an emerald green felspar; while the green granitel here implied seems a mixture of felspar and siderite with steatite, the magnesia having even

Of Vosges.

penetrated the felspar, and imparted its usual green colour, whence it has received its common appellation.

It is found in the Vosges mountains in France, and there is a manufactory at Paris, where it is cut into tables, vases, chimney-pieces, and other articles of decoration.

The fracture has the soft unctuous appearance of a magnesian rock, and the obscure green colour is a further characteristic of that class of stones, so that there seems little doubt but it must belong to this Domain.

Similar granitels are found, it is believed, in Westmoreland, and in Ireland. Occasionally some crystals of the felspar are large and regular, when it assumes the form of a porphyry.

MODE IX. MAGNESIAN LIMESTONE.

Many limestones are so much impregnated with magnesia, that their qualities become altered, and they are injurious to vegetation. According to Dr. Kidd, the limestone of parts of Derbyshire, Nottinghamshire, and Yorkshire, is of this kind; and at Matlock the limestone of the rocks on the side of the river where the houses are built is magnesian; on the other pure. Mr. Tennant has analysed the stone employed in two remarkable ancient buildings.

“STONE OF YORK MINSTER.	
Carbonic acid	47,00
Lime	33,24
Magnesia	19,36
Iron and clay	0,40
	100,00

“STONE OF WESTMINSTER HALL.	
Carbonic acid	47,16
Lime	33,48
Magnesia	17,76
Iron and clay	1,60
	100,00”

Dolomite.

But the most remarkable stone of this kind is Dolomite, resembling a primitive granular limestone, but which, according to many analyses, contains not less than 45 of magnesia, in the form of carbonate. This stone received its name from Dolomieu, who observed it among the remains of ancient sculpture at Rome; and afterwards discovered it in the mountains of Tyrol. It has been classed among the primitive marbles; but the essential difference is, that the influence of the magnesia prevents its effervescence with acids, unless previously pulverised, when the calcareous particles are affected by the exposure. It is also sometimes phosphorescent when scraped in the dark, and elastic in thin plates. It sometimes contains veins of green mica, like the primitive marble called Cipolino. In appearance it differs but little from granular limestone. The Apollo of Belvidere, and some other beautiful statues, are said to be formed of Dolomite.

Dolomite forms arrects, or uprights, extending from the base to the summit of the Alps of Tyrol; whence it has become a proverb in the country, that no mountain exists without a hat of limestone*. It is sometimes in large masses, sometimes in thin layers, alternating with foliaceous mica. Saussure, § 1929, observes, that most of the primitive limestones of St. Gothard are Dolomites; and they often contain the parasitic substance called tremolite.

STRUCTURE I. MAGNESIAN LIMESTONE.

From the North of England, and various other countries.

STRUCTURE II. DOLOMITE.

Aspect 1. Entire. From the ruins of Rome. From the Alps of Tyrol.

Aspect 2. Mingled. From St. Gothard, with tremolite.

The same, elastic, with foliaceous mica.

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* Patrin, ii. 309.

MODE X. GREEN MARBLE.

In most rocks the green colour betrays the presence of magnesia, whence it becomes an emphatic epithet. In the magnesian limestone this effect is not observable, because the minute talcous particles are intimately combined with the calcareous; but where they are aggregated apart, as in the green granitel and green marble, the colour becomes characteristic. The latter is also called sometimes serpentine marble, because in fact the green parts belong to the rock called serpentine, while the white are purely calcareous. These marbles have never been classed with glutenites, being neither bricias nor pudding-stones, but an irregular and original compound of serpentine and marble, in which the former is preponderant.

Verde-antico. The most celebrated rock of this description is that called the *verde-antico*, or ancient green, in which a green serpentine with dark spots, seemingly rather argillaceous, is interspersed with a pure white marble. This is the Laconian marble of the ancients, of which there were quarries near Mount Taygetus; and Pliny has rightly characterised it as more cheerful than any other. But the whole passage again deserves attention: "Some marbles are esteemed VERY PRECIOUS, as the Lacedemonian green, more cheerful than all the rest. So ALSO the Augustean, and afterwards the Tiberian; first discovered in Egypt in the reigns of Augustus and Tiberius. The difference between them and ophites is, that the latter is spotted like a serpent, whence it received the name; while the others present spots of a different form, the Augustean being crisped into wavy spots, while in the Tiberian the white (*canities*) is scattered, not convolved."

Such is this celebrated passage, which has led to many errors in mineralogy, as it has been conceived that the ophites was green porphyry, and that the other kinds were green; whereas it is clear from the subsequent part of Pliny's description, that the ophites was grey or whitish, being a spotted ollite, and when the spots were of golden mica it became the most esteemed *Lapis Thebaicus* of the ancients. In like manner the "*sic*, so the Augustean," only implies that both were esteemed very precious, like the Laconian, but not that they were of a green colour*.

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* For the ancient testimonies concerning the green marble of Laconia, the reader is referred to the learned work of Blasius Cary-

A recent French author gives the following account of the *verde-antico*; but he is certainly mistaken when he regards it as a bricia.

"The *verde-antico* should be considered as a kind of bricia, the paste of which is a mixture of talc and limestone, and the fragments, of a greenish black, are owing to serpentine more or less pure. This marble is an aggregate of white marble and green serpentine, reduced to angular pieces, or blended in its paste, and giving to it a green colour, more or less deep.

"The *verde-antico* marble of the finest quality is that of which the paste is of a grass green, and the black spots are of serpentine, of that sort called noble serpentine. It should also be sprinkled with white spots, which renders it more gay than when they are wanting.

"This marble is much esteemed in commerce, but large pieces of a fine quality are seldom found. Nevertheless there are four beautiful columns in the Hall of Laocoon, in the Napoleon Museum; but there are much finer ones at Parma.

"It was known by the ancients under the name of *Spartanum*, or *Lacedæmonium*; and we

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ophilus (Biagio Garofalo) *De Marmoribus Antiquis*. Traj. 1743, 4to. Some extracts may be found in the Appendix. See also the account of the ancient marbles in Domain V.

are informed it was dug in the environs of Thessalonica, in Macedonia, which at present forms part of European Turkey*.

"This *verde-antico*, properly so called, must not be confounded with the marbles known by the names of *vert-de-mer*, or *vert-d'Egypte*. The real *verde-antico* is a bricia, and never is mingled with red spots, while those just mentioned are veined marbles, mixed with a dull red substance which gives them a brownish hue, not very agreeable. Besides, it is one of those marbles which decompose in the open air."†

This decomposition is rather a proof that the darkest parts are of an argillaceous nature. Dr. Kidd regards the genuine *verde-antico*, which must be carefully distinguished from ancient green porphyry, and from mere serpentine, as "an irregular breccia, consisting of fragments of dark grey compact limestone, black argillaceous schistus, and white granular marble, imbedded in a species of serpentine, which here and there is of a uniformly green colour, and a considerable degree of transparency, very closely resembling jad, or compact talc.

"The fragments of white marble are very singularly fringed, as it were, with a green substance, which, proceeding in the form of close parallel fibres from every part of the edge, penetrates into each fragment to the extent of about the tenth of an inch.

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* A gross mistake, and glaring inconsistency.

† Brard, 333.

"This appearance is of difficult explanation; because it seems that the penetration, being so regular, and accommodated to the outline of the fragment, must have taken place subsequently to the formation of the breccia."

It is certain that different specimens of this substance have great variations, as probably they are from different quarries. In some the pieces of clay-slate easily detach themselves from the mass; but in the finest fragments the whole is so intimately blended together, and the general appearance so different from that of a bricia, that no artist nor antiquary has ever applied this name to the Spartan green. Parts of the new quarry in the Isle of Anglesea perfectly resemble the *verde-antico;* but no one has supposed that beautiful stone to be a bricia. The polzevera of Genoa is in like manner a green serpentine, with veins of white marble, but is never classed among the bricias.

Others, Antique.

There is another ancient and very rare marble, of a deep green, with little distant red and black spots, and fragments of entrochi changed into white marble. Another rare kind is called leek marble, being of a bright green, shaded with a blackish green, so as to form long veins; with a fracture in splinters like that of wood. There is a table of it at the Hotel de la Monnoie, at Paris*.

Modern. Polzevera.

Of modern green marbles, the polzevera, already mentioned, is so called from a mountain on the north of Genoa. This marble often presents red calcareous parts†, like that of Anglesea; but in the latter the red, and even the white, seem so intimately combined with magnesian particles, that they do not effervesce with the nitrous acid, while in the *verde-antico* the effervescence of the white parts is very strong. The polzevera is common in ancient chimney-pieces, both in France and England, for example, in the British Museum. There is also a green and white marble, found at Suza, in Piedmont.

Of Campan, &c.

The green marble of Campan, and other districts of the Pyrenees, also consists of limestone mixed with talc; but the structure is so singular, that it is classed among the Anomalous Rocks. The Isle of Elba also presents a white marble, veined with dark green; but the green marbles of Florence seem strictly to belong to serpentine, as probably does the *bisachino* of Sicily. A green marble, resembling the *verde-antico*, is also found at Grenada, in Spain.

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* Brard, 325.

† So our author, but the red seem serpentine.

What is called at Paris *marbre d'Ecosse* is a serpentine, from Portsoy. But one of the most beautiful green marbles yet discovered is that of

Of Anglesea.

Anglesea, which sometimes resembles the *verde-antico*; in other parts is interlaced with rose-coloured veins; and in others variegated with red and green of dissimilar intensity. It would appear, as already mentioned, that even the calcareous parts are much impregnated with magnesia, or, in other words, are Dolomite. This marble was long since described by Da Costa, and latterly by Coquebert.

MODE XI. MAGNESIAN INTRITE.

Serpentine porphyry.

The chief rocks of this description hitherto observed, are what have been called pot-stone and serpentine porphyries, the latter being found near Florence. The base is of the usual colours of these two substances, interspersed with larger or smaller crystals of felspar.

Magnesian intrites also exist with crystals of quartz, or calcareous spar.

To this Mode may be referred the following rocks, described by Saussure:

A steatitic rock, with crystals of rose-coloured felspar. § 154.

He describes, § 1437, what he calls a serpentine porphyry, but really an intrite with small crystals of actinote.

A hard green serpentine, with spangles of a brighter green, semi-transparent, and resembling wax; being seemingly a secretion, or confused crystallisation, of the purest parts of the stone. May not the same remark be applied to porphyries, &c.? § 959.

Steatite, crystallised in ollite, the crystals being laminar, and of a grey inclining to green. § 1851.

MODE XII. MAGNESIAN GLUTENITE.

This Mode presents, as usual, two Structures, the large and the small grained.

STRUCTURE I. LARGE-GRAINED.

Magnesian bricias.

A late ingenious writer gives the following account of two curious magnesian bricias, the latter however being more strictly a pudding-stone.

" 1. *Steatitic bricia of Corsica.* This bricia, the steatitic base of which is of a reddish white, contains fragments of the same substance, which are angular, in general small, some of which are of a blood red, and others of a grass green. This beautiful rock, which resembles in its paste the rock called lard-stone, used by the Chinese, was discovered by M. Rampasse in Corsica, in the department of Golo. I could have wished to have given it a more exact locality, on account that it would be highly interesting to work this beautiful steatitic bricia: but M. Rampasse constantly refused it.

"2. *Steatitic bricia of Monte Nero.* The steatitic bricia of Monte Nero is found in the little torrent of Orsara, in Liguria. Instead of a base wholly talcous, like the preceding, it consists of a calcareous base of a cherry red, with a granular and scaly fracture, and only its spots are owing partly to pebbles of serpentine of a pistachio green, and partly to some globules of laminar diallage. It sometimes happens that the spots of serpentine are surrounded with white rings, which farther relieves the richness of this beautiful bricia, which was discovered by M. Viviani, a learned mineralogist*. It is to be regretted that its site is not yet known, it being only found in detached masses, in the torrent of Orsara."†

Mr. Kirwan mentions among the bricias the

"* Viviani, Voyage in the Apennines of Liguria, p. 16."

† Brard, 482.

telgsten of Cronstedt, consisting of indurated steatite, mixed with micarel, or felspar, or schorl, or tourmaline; but this is rather a mingled magnesian rock, as is the serpentine, interspersed with quartz, mica, limestone, or garnets.

Some authors, as already stated, regard the *verde-antico* as a bricia.

STRUCTURE II. SMALL-GRAINED.

These have scarcely been observed*.

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* Perhaps the *rag-stone* of Da Costa, p. 173, is of this kind, being of a greenish grey, and of a talcous appearance. It is used as a hone to give a fine edge.

Pyrenees

DOMAIN V.

CALCAREOUS.

◆

CALCAREOUS EARTH.

THIS important substance is produced by burning limestone, marble, or chalk; and is commonly known by the name of lime. The purest is yielded by calcareous spar, or some white marbles.

Its taste is hot and acrid; and it is incapable of fusion, even by the burning-glass, It may however be fused when joined with silex or clay.

Limestone is composed of lime and carbonic acid. Heat separates the latter, and the lime is left pure. This acid is a species of gas, formerly called fixed air, and discovered by Dr. Black in 1756; an event which formed a revolution in the history of chemistry. Atmospheric air is composed of about seventy-four parts in the hundred of nitrogen, and twenty-six of oxygen: but the latter varies; and there is commonly one in the hundred of carbonic acid gas. Hence lime exposed to the air absorbs the carbonic acid, and may again become a carbonate, or limestone.

In architecture, mortar is composed of quick lime and sand; and when mixed with a proportion of iron, or manganese, it becomes extremely hard, even under water.

When combined with sulphuric acid, the calcareous earth forms gypsum, or selenite, which being burnt produces what is called plaister of Paris. The alabaster of the moderns commonly belongs to the same combination; while that of the ancients is often a stalagmite, or secretion of common limestone. With fluoric acid, calcareous earth becomes fluor, or fluate of lime.

The greater proportion of limestone is produced by the decomposition of marine shells; but the more ancient, which is crystallised, and presents no trace of such remains, is called primitive, being supposed as ancient as any of the rocks. It is in general easily distinguished from the other substances by the nitrous acid, formerly called aqua-fortis, which excites effervescence; but when mixed with magnesia, or much silex, this effect is slowly procured. Nor do gypsum nor fluor effervesce.

To these observations, which are chiefly extracted from Kirwan, Thomson, and Patrin, it may be added that, in 1808, Mr. Davy reduced lime to a metal, which had the colour and lustre of silver, and burnt with an intense white light into quick lime.

In some works of mineralogy the first three Modes of this Domain, and even the three succeeding, have been arranged as mere *sub-species*, or varieties of limestone. Strict chemical analysis may probably discover a different proportion of ingredients, as, for examples, more water of crystallisation in marble, and more or less silex or argil; and there is at any rate a difference in the mode of combination. But the chief use of any system being to assist the memory, even the strict precision of terms becomes mere pedantry, if it be not subservient to this main object. Too large masses of colour, or too small, will render the picture equally inelegant and obscure.

MODE I. MARBLE.

Characters. Texture, large or small grained, generally in distinct concretions; sometimes so fine grained as to appear compact, and only distinguishable by its glimmering lustre: admitting a fine polish.

Hardness, of course marmoric. Fracture, foliated. Fragments, amorphous, blunt.

Weight, granitose.

Lustre, from glimmering to shining; between pearly and vitreous. Somewhat translucent, but the black only on the edges.

It chiefly consists of about 50 lime, and 40 carbonic acid; whence it is called by chemists a carbonate of lime.

The most common colours are white and black; but the others are so numerous, that they may be best observed in the subsequent enumerations of various kinds of marble.

For the geognostic relations of this celebrated rock, the reader is referred to Mode III., where, in treating common limestone, a wider field of observation may be opened.

Mineralogists have sometimes regarded those marbles as primitive which present what they call a granular fracture, of a shining or saline appearance; while those with a dull earthy fracture were regarded as secondary. But Brard has well observed, that a true white saline statuary marble, presenting every character of the primitive, may be of very recent formation, as appears from the constant depositions of the waters of St. Philip, in Tuscany, and of several other regions. Marbles of an earthy fracture have been found even among those esteemed the most primitive of the Alps.

Marble is distinguished from limestone by superior weight, and by superior hardness and compactness, so that it assumes a brighter polish. But many of the alabasters will scratch marble, being of course of a still harder nature.

Use in architecture.

While the Egyptians often employed the eternal granite, the Greek and Roman architects, who required greater roundness and softness of forms, chiefly used marble, as more easily wrought, and likewise more abundant in their countries. Nor does its duration seem much inferior to that of granite, or porphyry, when sufficiently pure and unmixed with argil; for not to mention the beautiful statues (which are often under shelter), ancient temples have suffered more from the hand of bigotry or barbarism than from the lapse of time. Marble is however exposed to accidents which could not affect granite, or porphyry. A singular example occurs in the ruins of the temple of Serapis, on the delicious coast of Baiæ, where three large columns of Cipoline marble are pierced by pholades, a kind of sea snail, which penetrate deep holes into limestone, whence they are extracted, and called sea-dates, being a luxury of the Italian repast*. These perforations extend to not less than sixteen feet above the level of the sea; whence some have argued that the latter has subsided, while others suppose that the land has been raised by earthquakes. A more probable and easy solution would be, that these columns have belonged to some more ancient edifice, which may have been ruined by an earthquake, and fallen into the sea; or the ship which conveyed them may have been wrecked; or, in fine, the pillars left partly within the sea mark for a certain space of time. For in this very temple, the Pentelican marble of Attica, and the African bricia, occur; and it is well known, from many examples, that the Romans transported obelisks and columns from many countries, to adorn Italy.

Temple of Serapis.

Primitive.

The celebrated Buffon had advanced an opinion, that all calcareous rocks were mere remains and depositions of shell-fish, and other marine animals. The first who combated this opinion was Palassou, in his celebrated essay on the mineralogy of the Pyrenees, published in 1781; but which, through the excess of admiration for Buffon, fell into oblivion. The opinion was however soon after revived and confirmed by that illustrious observer Saussure, especially in the latter part of his journeys among the Alps. Patrin says that he has frequently himself observed, in the immense mountainous chains of Northern Asia, from the Uralian to the river Amur, for an extent of more than 1000 leagues, beds of marble, which it was impossible to suppose for a moment to have been posterior to the other beds of primitive rock, in which they were enchased. He also regards the chains of calcareous hills, mingled with clay-slate and serpentine, which appear at the bottom of the Alps, and other lofty mountains, often in layers contorted in the strangest forms, but still unbroken, as being caused by the tumescence of the granite, while these depositions were still of a soft consistence.

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* Breislak, ii. 163.

" Where the thickest calcareous beds subsided in themselves, they formed homogenous masses, without any divisions, or at least there are only accidental fissures. These marbles are granular, and palpably crystallised in all their parts; they are generally of a single colour, white, grey, red, or black, and without any mixture of foreign substances, except a small quantity of silex, which is intimately combined, and whose presence is only found by dissolving them in an acid. I have tried some of the purest specimens in this manner; I always obtained a quartzy sediment; the quartz at times is so abundant, that these marbles yield sparks against steel.

" It is these large masses of homogenous marbles which furnish the fine white statuary kinds, such as those of Paros and Carrara: they are never in any very elevated situation.

" Those which are found interplaced between schistose layers, or mixed with beds of serpentine, yield the marbles called *Cipoline*, which present long veins parallel to each other, and undulated in various directions. These may be met with in the neighbourhood of the summits of mountains.

" I have no need to mention that these marbles never contain any vestige of shells, nor other marine productions, as their formation is much anterior to the existence of all organised bodies.

" Some are found which contain garnets, octaedral iron, and even pyrites, the same as primitive schisti. Romè de l'Isle says, that in the finest white Carrara marble he has seen blackish spots and veins, produced by a multitude of very small crystals of octaedral iron, affecting the magnet, exactly like those which are found in the ollites of Corsica.

"Ramond, in the interesting description which he gives of the peak of Eres-Lids, near Barège, says, that on the summit of that mountain calcareous beds are observed, which constitute a greenish-white primitive marble, entirely sprinkled with small duodecagon garnets, round, opake, of the size of the head of a pin. Another variety presents garnet in large irregular crystals. These beds of marble alternate with beds of rocks which are indubitably primitive.

"I have already observed, that calcareous bricias are nothing else than the primitive marbles themselves, the beds of which have been overturned, while they were still in a soft state."*

It is equally probable that the calcareous and argillaceous rocks may, in a soft state, have subsided from the granite, which had previously crystallised in arrects of great steepness.

Arrangement.

The subject of marbles is almost infinite, as no mineral substance affords such innumerable diversities, or has so much attracted the attention of mankind. In a scientific point of view, subservient to the general plan of this treatise, they may be divided into four principal structures; the Granular; the Compact; the Conchitic, or that containing shells; and the Zoophytic, or that with madrepores, &c.; beginning with those found in ancient monuments, and ending with the more modern; the colours being merely regarded as *varieties:* though some, from their rarity and singularity, as, for example, the white venular marble of Durness, and lumachellas of Bleyberg and of Castracan, or Castravan, in Syria, falsely ascribed to Astracan, ought rather to form-*diversities*. The bricias, and some others, will of course be described among the Calcareous Glutenites*.

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* Patrin, ii. 304.

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* The division of marbles by a scale of colours, proposed by Daubenton, has been found alike useless and impracticable. Besides the six divisions here adopted, of Granular, Compact, Conchitic, Zoophytic; with Serpentine marbles, and Glutenites, there might be the following subdivisions, or aspects:

Uni-coloured, white, black, red, &c.
Straight-veined.
Mazy, with irregular short veins.
Mixed, equal spots of various colours.
Spotted, large spots.
Speckled, middling spots.
Dotted, small spots.
Ocular, like eyes, *occhiato*.
Streaked, long spots, &c. &c.

STRUCTURE I. GRANULAR.

In general the ancient and finest marbles belong to this description; though an ancient white or grey, called *palombino* by the Italians, and that of Proconnesus, not to mention a few others, are of a fine earthy grain, almost compact.

Egyptian.

The first attention is due to the Egyptian monuments, as from that country the arts passed into Greece, and subsequently into Europe. The marble statues and fragments described by Wad are very small, from 10 to 20 inches in height, and present the following colours; milk-white, the same with venular silver-white mica, greyish white, passing to blue, and yellowish white. The chief Egyptian monuments are in granite and basalt.

Rosso antico.

But in the Museum at Paris, and other princely collections, there are many Egyptian statues, and other monuments, in the *rosso antico*, the ancient red, the peculiar marble of Upper Egypt, or of Ethiopia, for the cataracts were anciently reputed to divide these countries; and Syene was esteemed the last town of Egypt, on the very confines of Ethiopia.

It seems evident, though it has escaped all the critics, antiquaries, and mineralogists, that the superb *rosso antico*, which, in the grand statues of Agrippa (formerly in the Pantheon), the Antinous, Indian Bacchus, and other exquisite remains, surpasses in beauty all the other marbles, is the celebrated *Augusteum* and *Tiberianum* of Pliny.

1. It is allowed that this marble was from Egypt; and, even in the time of Pliny, was carefully distinguished from porphyry, which came from the same country.

2. It was natural to give the imperial name to the imperial colour, which was red, as is known to every classical reader, and the very name of porphyry evinces. Our purple is the *purpura violacea*, or violet purple of the ancients.

3. The other colours were celebrated before. The black was called Lucullean, from Lucullus, as Pliny says. The green of Laconia, the yellow of Numidia, were all well known: and red was the only new colour of marble. Boöt supposes that the Augusteum was *cinereum*, of an ash grey, because it is ranked with ophite: but several well-known Greek and Italian marbles were of this very common colour.

4. The *rosso antico* alone presents the singularity mentioned by Pliny, and which he conveys, as usual, in the most chosen and emphatic language: *Tiberianum* SPARSA *non convoluta* CANITIE*. For the ancient red is often sprinkled

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* Edit. Brotier. Some erroneously omit the *non*.

all over with white dots, like hoar frost. The *Augusteum undatim crispum in vertices* is the *rosso fiorito* of the Italians, with little tufts or flowers of white.

5. Because the other stones, mistaken for the Tiberian and Augustean marbles, are now known not to be Egyptian, just as the green porphyry, or pretended ophite, is not Egyptian.

The *rosso antico* therefore is rightly styled Egyptian[*]. Brard describes this beautiful marble as of a deep blood red, with little distant black or white veins, and often sprinkled with little white dots. Such is the Egyptian Antinous; but two ancient seats used in the baths, and the bust of an Indian Bacchus, are free from the veins, though the dots be always visible. The celebrated statue of Agrippa, son-in-law of Augustus, in the Grimani palace at Venice, is of this imperial marble, intended perhaps as a special compliment[†].

The *rosso annulato* is red, with round white spots; the *seme santo*, red, with little triangular spots. One of these may be the *Claudianum*[*], if it be not another name for the Tiberian. Gordian's villa had fifty Carystean columns (green); fifty Claudian (red?); fifty Synnadian (white, spotted with bright red, *porto santo*[†]); fifty Numidian (yellow).

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[*] Imperati, and Wallerius, i. 134, say the *rosso antico* was from Upper Egypt. As Syene was on the borders of Ethiopia, it is also called *Ethiopicus*. (See App.)

[†] A good engraving is given in Dr. Pococke's Travels in the East, vol. ii.

Of Paros.

In passing to the Grecian first occurs the white marble of Paros, sometimes called *lychnites* by the ancients, because the quarries were explored by lamp-light. A transparent kind, called *phengites* by Pliny, was also found in Cappadocia, and is said by Chardin to occur in Persia. Domitian is reported by Suetonius to have formed galleries of a kind of stone that reflected the figures of persons behind him, corruptly called *phengites*, while it was probably a fine black marble.

The Parian marble was employed by the most ancient Greek sculptors, about the fortieth Olympiad; but being of a yellowish tint and coarse grain, it was afterwards supplanted by the marble of Luna, in Etruria, as afterwards by that of Carrara, in the same vicinity.

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[*] Hist. Aug. 676.

[†] Perhaps the *fiore de persico*, or peach blossom; but travellers may observe the original quarries in Natolia.

The *rosso antico*, when unpolished, is of a dark dull appearance, which obscures its difference from ophite. But as, in treating of metals, Pliny begins with gold and silver; and in gems, the diamond and the emerald; so in marbles he begins with the *most precious*, as he says, the Laconian green, the Egyptian (red), and ophite. Any relation of colours or qualities is not in view, but only the *value*.

In the great museum at Paris, the Venus de Medici, Diana hunting, Venus leaving the bath, the colossal Minerva, the Juno of the Capitol, the Ariana called Cleopatra, and several others, are of Parian marble. The celebrated Parian tables at Oxford, which have illustrated many points of ancient chronology, are also inscribed upon the same stone.

Pentelican.

Pentelican marble, from the vicinity of Athens[*], is white, like the former, but with a finer and more compact grain. It sometimes presents blackish veins from a siderous mixture, and sometimes green veins of the talcous kind, so that it is at Rome called statuary Cipoline.

Most of the noble monuments of ancient Athens are constructed with this marble; and several statues are extant, as in the Museum of Paris, a Bacchus in repose, a Jason, a Paris, a tripod of Apollo, &c. &c.[†]

Greek, so called.

The vague name of *Greek* marble has been given to a fine-grained and hard kind, of a snowy whiteness. It was from several islands in the Archipelago, as Scio, Samos, &c. In the Parisian Museum, which derives its name from the Emperor Napoleon, there are an Adonis, a Bacchus, the philosopher Zeno. The Fawn is supposed by Brard to be of the marble called Coralian by Pliny, because found near the river Coralus, in Asia Minor, and which, in whiteness and grain, resembled ivory. Some assert that the finest statue in the world, the Apollo of Belvidere, is formed of what is called the Greek marble; but most mineralogists infer it to be marble of Luna.

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[*] Concerning the mines of Attica see Xenophon *de Vectigalibus*.

[†] Brard, 394. Petrini says, ii. p. ix, that the Pentelican, with mica, has grains of chalcedony, as the Carrara has rock crystal: probably from a mixture of argil.

Translucent. At Venice, and in different towns of Lombardy, are columns and altars of a singular marble, so translucent, that the light of a candle is visible through pretty thick masses. This is perhaps the Cappadocian *phengites*.

Elastic. Tables of ancient elastic marble occur in the palace Borghese at Rome. It has been recently asserted that this quality may be imparted by a certain modification of heat, which loosens the structure, so that the calcareous scales move in certain directions.

Of Luni, in Italy. White marble of Luni (the ancient Luna), or Carrara, on the shores of Tuscany. Though these two places be nearly adjacent, yet some assert that the marble of Luni is finer than that of

Carrara, and free from the grey veins that sometimes appear in the latter. The Antinous of the Capitol is said to be of marble of Luni. That of Carrara, as just mentioned, often presents grey veins, so that it is difficult to procure blocks of an uniform white. It has been much used for chimney-pieces in England; and is often mingled with the yellow and dull purplish bricia of Sienna: but the quarries are said to have been opened at least as early as the time of Julius Cæsar. The Carrara marble has sometimes greenish talcous veins, like the cipolino, and sometimes crystals of iron. But the most beautiful specimens are those which contain, in little cavities, rock crystals of the purest water, called in Italy diamonds of Carrara.

Of Hymettus.

White marble of mount Hymettus, in Attica; rather inclining to grey: but it was the first foreign marble introduced at Rome, where this moderate magnificence was thought so extraordinary, that Crassus the orator was exposed to the sarcasms of Marcus Brutus, because he had adorned his house with six columns, twelve feet high, of Hymettian marble. Such were the chief white marbles employed by the ancients.

Ancient black.

The ancient black is so intense that, when placed beside those of Dinan and Namur, it makes them appear grey. Some pedestals and busts of

SCOTLAND.—White statuary marble of Assynt. White marble, with long veins of a different tint, from Durness. Red and white marble of Boyne. The beautiful rose-coloured marble of Tirey, mingled with siderite, &c. is reserved for the Composite Rocks. The same isle presents a beautiful white marble, with veins of nephrite. Numerous other marbles might be explored in the Highlands of Scotland; and a French author is singularly unjust when he says that the British

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with white, mentions the Egyptian, which he rather supposes to be the Tiberian and Augustean (though no green marble be found in Egypt); then a second, which is the polzavera; and a third the green of Susa; and a fourth from Sweden. He then adds, "These are the chief varieties of this marble, which, besides the places already mentioned, is found in several parts of Europe; in the northern part of the island of Anglesea, in Wales, in the parish of Llan Fairyng Hornuy; and in Inis Molroniad, or the Island of Sea Calves, there are rocks of this kind of marble with veins of fine asbestos; and a quarry of the same marble is dug near Kemlyn, and another at Monachty, in the same island.

"Woodw. Cat. A. X. b. 3, exhibits a dusky green marble, veined with white, which he found in the way between Ambleside and Penrith, in Cumberland, where it is in considerable quantity: it probably is of the same species."

So ancient is the knowledge of the beautiful Anglesea marble, which has been regarded as a recent discovery. In the Journal des Mines[*] is an extract from Pennant's Tour in Wales concerning this marble; which is also said to be found in the Skerries, a little isle near Anglesea.

[*] No. 16, p. 75.

Isles are poor in marbles[*]. It is only the fashionable rage after foreign kinds, joined with an old routine of commerce, blindly followed by the manufacturers, which prevent vast treasures of this decoration from being discovered in Great Britain and Ireland; particularly in Wales, and the Highlands of Scotland.

IRELAND.—Near the celebrated lake of Killarney are found white and red, and black and white marbles. Indolence and ignorance have prevented further research. The fine black marble of Kilkenny is conchitic; but the north of Ireland yields a brown marble, and one of a pale white, like earthenware[†].

Having begun with these northern regions, it may be proper to continue in the same climate, that the comparative view may become more distinct.

NORWAY.—The marble of Gillebeck, which resembles that of Tirey, will be described among the Composite Rocks. Even the Danes show a more patriotic taste than Britons, for it has been employed in constructing the church of Frederic at Copenhagen. Many other Norwegian marbles are faintly described by Pontoppidan and Fabricius; but there is no encouragement for the exploration.

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[*] Brard, 442. Some of the Assynt marbles promise well, but the quarries are not yet sufficiently deep to expect the finest kinds. Those of Italy have been worked for 1500 years. Adits might be found advantageous.

[†] Da Costa, p. 210, says a grey marble, with white spots, from the county of Cork, was much used in Ireland.

DENMARK.—The Danish islands present some coarse marbles, but none has attracted particular notice.

SWEDEN.—This country has evinced its good sense and patriotism in establishing considerable manufactures of porphyry and ollite; but marble seems rare and of little value.

RUSSIA and SIBERIA.—On this subject there cannot be a better guide than Patrin, who resided many years in these regions.

" In Siberia, the Ural mountains furnish the finest and most variegated marbles. The greater part are taken from the neighbourhood of Ekaterinburg, where they are wrought, and from thence transported into Russia, and particularly to Petersburg. The late empress caused an immense palace to be built there, for Orlof her favourite, which is entirely coated with these fine marbles, both inside and out. It is situated on the bank of the Neva, and is one of the chief ornaments of that capital. This empress built the church of Isac with the same marbles, on a vast space, near the statue of Peter the Great. This church was not finished in 1787. I there saw columns, of very large dimensions, which seemed to me to be of a single block, of a white and bluish marble, in large veins: only this kind of marble was used in this church. The palace of Orlof has many varieties, which are distributed in compartments.

"I saw no white statuary marble in the Ural mountains; but in that part of the Altaïan mountains which is traversed by the river Irtish, I in two places saw enormous rocks of marble, perfectly white and pure, from which large blocks might be hewn. The only use made of it is to convert it into lime, for the service of the fortresses situated along the Irtish."*

Grotto of Kungur.

The celebrated grotto of Kungur is by some said to be in a coarse white marble, by others in alabaster. The village of Kungur is near the skirts of the Uralian chain, on the confines of Europe and Asia, about fifty miles to the S. S. E. of the city of Perm, in the government of the same name. It is said to be six wersts, or about a league, in length, and half as much in breadth. There are several openings in the roof, so that there is a subterraneous meadow with grass and flowers, a little lake, a rivulet rising from a detached rock, which, like another springing from a pool, soon loses itself underground; with natural stairs; an image of St. Nicholas, and crosses erected by the Russians. Gmelin, who occupied five or six hours in visiting a part of this remarkable grotto, adds, that it is not after all so singular as that of Bauman in the Hartz, and as the Neble Loch, or Misty Hole, in the Duchy of Wirtemberg *.

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* iii. 8.

On descending to the more southern kingdoms, we find the Turks occupied in converting the noblest monuments of Greece into lime; instead of exploring the ancient quarries of the islands, among which Anti-Paros displays its celebrated grottos in the purest white marble, with rich stalactites and stalagmites of the same beautiful substance; and said to be as saline as that called primitive. The beautiful green of Laconia is alike unknown to these barbarians.

GERMANY.—White marble of Ratisbon. That of Hildesheim approaches to ivory; and the same place likewise furnishes an ash grey. Wolfenbutel, greyish white. Osnabruck, fine black. Ostergyllen, spotted, white, yellow, and deep grey. Between Leipsic and Bareuth there is a quarry of chesnut and liver-colour, with veins of deeper tints. Ash grey, with black ramifications, from Goslar. Green, veined with yellow, probably a

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* See his Journey to Siberia, in the *Hist. Gen. des Voyages*, tom. 24, 4to. p. 128, where there is a ground plan.

serpentine, from Salzburg. Red, from Ratisbon, Bohemia, and Trent. Straw yellow, with black dendrites, from Hessia. It is only formed into little pictures; and, like the Florentine, is a marlite abounding in argil.

SWISSERLAND.—In general dull violet, spotted or veined with black. There are some of a bluish grey, resembling what is called the blue turquin, which comes from Africa, and is spotted with siderite, and the blue marble of Narbonne; both of which however should be called grey, for no blue marble has hitherto been discovered, that colour being almost peculiar to the precious stones; but it appears in alabaster, a blue translucent kind of which is found near Nottingham*.

FRANCE.—The most singular is perhaps the blue of Narbonne, described by Patrin as of a deep blue, spotted with bright grey. Brard says that it is white, mingled with bluish grey, and is in the highest esteem, being sometimes improperly called marble of Languedoc. Of the beautiful red marble, which forms many chimney-pieces at Chantilly, often spotted with a deeper colour, and sometimes with white spar, I cannot discover the site, if it be not the *griotte* of Canne, not far from Narbonne*, which is a deep red, spotted with white, or the Serrancolin, which is of a fair red, mingled with yellow and grey, and is dug near the river Neste, which joins the Garonne. Patrin says, that fine large blocks of Serrancolin have been raised for the decoration of the royal palaces of France. The Pyrenees furnish many marbles, as the green and red of Campan; and, among others mentioned by Palassou, the pure primitive white of Loubie, the grey of Barège, the red of Serrancolin already mentioned, with those of Seix, mingled with argil and talc, like the Campan. Red, with yellow spots, from Poitou. Pale red and yellow, from Tournus, which decorates many churches at Lyons. Grey, veined with white and golden yellow, from Bourbon-Lancy. Red, with white veins, from Caen in Normandy. That of Marquise, near Boulogne, with large yellow spots and red veins. Many of the Flemish marbles are black, veined with white; the others chiefly belong to the Conchitic or Zoophytic divisions.

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* The mountain of Cramont, near Mont Blanc, is composed of a coarse marble, of that kind which the Italians call cipolino; the base being large-grained, and confusedly crystallised, of a slate blue, with white veins and spangles of mica. Sauss. § 915.

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* So says Patrin; but I can only find one *Cannes*, near Antibes. Brongniart says *Cosne*, in the department of Allier. Marbles, like jewels, being common objects of commerce, many frauds are practised, and many errors in consequence arise. But an eastern marble, probably the Synnadic, is compared, by Tournefort, with the red and white of Cosne in Languedoc.

To these may be added the following, indicated by Brard. Spotted with red, white, grey, and yellow, from the vicinity of Mont Dauphin, in the Upper Alps. White, rose, and green, mingled with garnets, needles of lepidote, and shining spangles of iron; this beautiful marble, of a saline grain, is found at St. Maurice, in the Val Godmar, but it belongs to the Composite Rocks. St. Maurice likewise furnishes cipoline. Deep violet, spotted with yellow, from Narbonne. *Bariolé*, or streaked with various colours, white, red, and yellow, from the mouths of the Rhone, much esteemed, being called marble of St. Baume, and reputed equal to Spanish *brocatello*. White, veined with grey, from the department of Mont Blanc, very hard, being combined with silex. Grey and white, spotted with red, from Liege. Of a light coffee colour, with white, grey, and red veins, from Boulogne. Of Antin, white, with veins of a fiery red. Lilac, from the Pyrenees. Black of Dinan, bituminous: it is sometimes powdered with white spots. Black, or rather grey, of Namur, much used in Holland*. Isabella colour, with transparent spots of deep brown, from Mont Rouge, near Paris. Yellow, with black dendrites, from Rouen. Of St. Maximin, department of Var, much esteemed in commerce, and called *portor*, or the gold-bearer, because in that of the best quality it is black, veined with golden yellow[*]. White, from Civrai, reputed too hard by the marble-cutters, while this is in fact a perfection of marble.

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* Where it is called *blaeuwe stein*, or blue stone. Hill, perhaps, thought Namur a town in Africa; for he gravely affirms this to be the Numidian marble of the ancients, which is literally *toto cælo errare*.

Many curious marbles are also found in the isle of Corsica, now subject to France, as the cipoline of Corte; and the isle of Elba has immense quarries of white, veined with blackish green, and also the cipoline.

The French make great use of marble, in tables of all kinds, &c. &c.; to which practice may in part be owing the infrequency of conflagrations, and no insurance company could derive the least advantage in that country.

SPAIN.—The milk-white of Cordova. Near Filabres there is a mountain, about a league in circuit, and 2000 feet in height, which is one entire block of the purest white marble, and capable of the highest polish. This singular mass is about three leagues from Almeria, in Grenada. The famous palace of the Alhambra, at Grenada, is partly constructed from the white marble rocks around the town of Molina, in New Castile. In the neighbourhood of Grenada, white saline marble, slightly tinged with red. Similar, but of a finer grain, from Badajos in Estremadura. White, with large grey spots, from La Mancha*. Grey, from Toledo. Grey, veined and spotted with white. Black, with grey and white, from Moron, La Mancha, and Biscay; which last also furnishes a black, veined with ochre red. Violet, elegantly spotted with bright yellow, from Tortosa: this is the celebrated *brocatello* of Spain. Dull red, veined and spotted with a lively red and shining white, resembling *griotte*†. Of a dull violet, like wine lees, with little orange spots, from Valencia. Flesh-coloured, veined with white, from Santiago; and there is also an entire mountain of this kind near Antiquera. Fawn-colour, powdered with grey, Cortegana. Dull red, with black capillary veins, Valencia. Near Morviedro there is a hill of black marble, veined with white, which gràdually passes into a yellow, blue, and red bricia, at the summit. Red, yellow, and white, of Molina. Red, veined with grey, from Guipuscoa. The others are Conchitic and Zoophytic marbles and bricias.

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[*] Da Costa, p. 203, says it was much used in England.

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* The French call such a marble *Tigré*, it should be *Leopardé*. The tiger is barred, the leopard spotted.

† *Griotte* seems originally to imply a large deep red cherry. The round dark spots might occasion the name.

PORTUGAL.—The mountains of Arrabeda furnish some esteemed marbles. That of Troncao is a pale yellow, with grey veins, and sometimes contains shells.

ITALY.—The chain of the Apennines being chiefly calcareous, and Italy the seat of numerous ancient monuments, and the parent of modern sculpture and architecture, it is no wonder that the Italian marbles have been highly celebrated. White marble of Padua, Pisa, Pilli, and Biancone, all used in architecture in the north of Italy. The cathedral of Milan is built with a white saline marble, veined with grey, from Mergozzo*. Black marble of Bergamo, of the most pure and intense tint, and finest polish, whence the Italians call it *paragone*. Black of Como, employed in the cathedral of Sienna. Deep black, with pure white veins. *Polveroso*, or powdered marble of Pistoia, sprinkled with little dots, so as to appear dusty. White, with large black spots, from Lago Maggiore, used in the decorations of most of the churches of the Milanese. The green of Florence belongs to the magnesian, as does the *verde-di-Prado*, so called from the little town of Prado, but, as others say, from Corsica*. Slate blue, veined with brown, from Margorre. Of Brema, yellow, with white spots. Light red, spotted with white, from the Veronese. Bluish grey, or what is called blue, of Rosso†. White, with little spots, and dots of blood red, from Luni. The yellow of Sienna is one of those called *brocatelli*, or embroidered, the colour resembling the yolk of an egg, in large irregular spots, surrounded with veins of a dull purple. The commerce with Livorno, strangely corrupted by our seamen into Leghorn, has rendered this marble very common in England. It is certainly beautiful, but far inferior to the green of Anglesea, or the rose, spotted with green, from Tirey. Yellow, veined with black, also from the neighbourhood of Sienna‡. The curious marble of Florence, stained with resemblances of ruins, &c. and which, with the dendritic, might be styled *pictorial*, being framed like pictures, properly belongs to the marlites. Orange, or bright red inclining to yellow, like the gem called jacint, from Verona; but as it sometimes presents ammonites, it rather belongs to the Conchitic: the tomb of Petrarca, at Arquoi, recently engraved by Faujas, is of this marble. A duller red was used by the Romans in building the vast amphitheatre of Verona. Six leagues from Verona Faujas observed a singular kind, which he calls bone-marble, being of the same red paste, with a greenish shade, and presenting large white spots, which are petrified bones; but he has not explained to what animal they belong. Large columns of this singular marble have been extracted *.

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* The primitive marble, white, with some veins of grey, and of which the cathedral of Milan is constructed, leaves in the nitrous acid white quartzy sand, with some pyrites and greenish siderite. Sauss. § 1771.

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* What is called the Egyptian green, is a polzevera from the vicinity of Genoa. It is so called because it resembles the *verd antique*, which was supposed to come from Egypt. See Da Costa, p. 200. Patrin says it is from Carrara.

† The *pavonazzo* should be a *purple*, or dark blue.

‡ At a place about nine miles distant, called Mont Arrenti, at the head of the vale of Rosia.

Sicily. The chief marble of Sicily is red, with long stripes, like ribbons, white, rose-coloured, and sometimes greenish, which at intervals revolve, forming pretty acute angles. This singular marble is of the highest value †. Bisachino not only presents a milk white, but an apple green, which takes the finest polish, probably a serpentine. Trapani possesses a red, with deeper spots; and another red, spotted with green; not to mention

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* Brard, 418.

† It is a heavy ferruginous kind, whence our marble-cutters call it *Sicilian jasper*. It is perhaps from Giuliano, in the south-west of Sicily, a spot famous for products of this kind.

grey, spotted with several colours, and one composed of spots red and yellow. Castro Nuovo, yellow, spotted with red. Taormina, red, spotted with black, or a deeper red; yellow, spotted with white and black; and a yet more singular, greenish, with bright brown spots; and a lilac, with wavy reflections. Termini, greenish, veined with white, and dotted with red. Near Sciacca appears a bright green, waved with deeper green and yellow. In the river Niso are found fragments of red, spotted with a white semi-transparent substance, like chalcedony.

Asiatic.

As marble so much abounds in Europe, there was no occasion to import it from the other continents, and their products of this kind remain of course little known. In ASIA Dr. Shaw mentions a dendritic marble of Mount Sinai, which has been confounded with the pictorial marble of Florence, as appears from Wallerius. Persia contains many marbles, mentioned by Chardin, particularly the translucent white. The kingdom of Siam, and China, also present edifices of beautiful white marble. Hindostan does not appear rich in this production. Some of the statues and monuments are rather of a coarse limestone than a marble.

African.

The AFRICAN marbles were among the most celebrated of antiquity, when the northern part of that continent was possessed by the Egyptians, Carthaginians, and various Greek colonies, and afterwards ruled for many centuries by the Romans. As the intercourse with Italy remained frequent till the seventh or eighth century, there is the less occasion for wonder that the tradition of the Roman artists should have preserved the distinctions of some African marbles; and as they are not numerous, it will be more satisfactory to consider them all in one point of view.

What is called the ancient red, already described. This is dotted or powdered with white; but there is another kind with white spots.

The dark red, with small triangular white spots, must also be classed among the African; and the red, with spots like flames. Similar marbles are called *fioriti*, among which is a white or grey, with purple flames[*].

Numidian.

The ancient yellow, according to Boot and Walerius, and many ancient authorities, was from Numidia; as was the grey with yellow spots. Pliny, who informs us that ships were built for the sole purpose of importing marbles[†], mentions the Numidian and Synnadic as being variegated by art, with inserted fragments. He reproaches the bad taste of those who altered the natural appearance of marble, by insertions added to the natural spots, so as to represent animals and other objects*; whence the Numidian was diversified with artificial eggs, and the Synnadic with rich crimson spots, instead of the dull red furnished by nature†. In another passage he says that Lepidus first used Numidian marble in his house, even his threshold being paved with it; whence he incurred public reproach for the new luxury‡. Four years after, Lucullus brought a marble to Rome, which was called Lucullean, being black, and found in an island of the Nile. But luxury assumed a far wider career, for ages after the time of Pliny; and many marbles unknown to that illustrious author must have been imported from Africa, and other countries.

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[*] For the African bricia see the Glutenites.

[†] xxxvi. 1.

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* xxxv. i.

† This precious marble was brought from the very centre of Asia Minor, Sinnada, or Synnada, being a town in the greater Phrygia. Strabo says, lib. xii. "Sinada is a town of no great size, before which is a plain of about sixty stadia, planted with olive trees. Further on is the village of Docimia, and the quarries of Sinadic stone; for so the Romans call it, but the natives Docimite. At first only small pieces were extracted; now, on account of the prodigious luxury of the Romans, immense and entire columns are hewn out, the stone approaching nearly to the *alabastrites* in variety. Many loads of this kind are carried down to the sea; and columns and tables of admirable size and beauty are exported to Rome."

See the Appendix, for a fuller account of the Synnadic, African, and other ancient marbles.

‡ xxxvi. 6.

A singular marble is still known to be found at Sitifi, in the north of Africa, being the proper turquin, because, like the turquois, it is supposed to be brought from a country subject to the Turks*. It is of a bluish grey, or slate colour, with spots of siderite or hornblende; and seems to be one of the most primitive.

American. The common marbles abound in AMERICA; and the conchitic is found at the height of 12,000 feet in the Andes. The following observations are from Molina's admirable essay on the natural history of Chili.

"The calcareous stones which this country furnishes, are limestones, marbles, calcareous spar, and gypsum. Among the limestones some are found very compact, and of all the colours; as are the coarse-grained, while the common limestone is white, bluish, and grey. The marbles of a single colour hitherto discovered are, white statuary marble, black, greenish, yellow, and grey. Two mountains, the one in the Cordelera of *Copiapo*, and the other in the marshes of *Maule*, entirely consist of marble in zones of several colours; but in such strata as surround the mountains, from their base to the summit, with a symmetry that seems an artifice of nature. The variegated marbles are, the grey, with white, yellow, and blue veins; green, speckled with black; and yellow, with black, brown, and green irregular spots. This last, the quarry of which is at San-Fernando, the capital of the province of Colchagua, is in great esteem, because it is easily wrought, and hardens in the air. All the marbles of Chili are generally of a good quality, and all take a good polish. Persons who have had occasion to examine the lower Andes, have assured me that those mountains abound in marbles of different qualities, and nearly of all colours; but the accounts I have received are too superficial to enable me to give exact descriptions of them. In the plains near the city of *Coquimbo*, a white shell marble has been found, somewhat granular, three or four feet under the vegetable earth. The shells in this marble are more or less entire, and give it all the appearance of a real *lumachella*. The bed of this marble extends in length and breadth more than three miles; its thickness, generally about two feet, varies, and depends on the number of the beds, which are sometimes five, sometimes eight. These beds are almost always divided by very thin layers of sand. This stone increases in hardness in proportion to its depth. The first beds only present a coarse friable stone, of no use but to make lime: the following, although compact, easily yield to the iron instruments used to cut it, and raise it from the quarry; but in building acquire a sufficient hardness to resist any impression of the air or water."*

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* Some say turquin, *turchino*, is derived from the blue colour of the turquois.

Many curious marbles are also found in New Spain, and in North America. The chief quarries in the territories of the United States are at Stockbridge, and Lanesborough, Massachusetts; sundry places in Vermont and Pennsylvania; Amenia, in New York; and in Virginia: some of which fully equal the finest specimens from Europe†. At Marble Town, near Hudson river, are quarries of fine black marble, spotted with white shells.

STRUCTURE II. COMPACT.

This division has scarcely been observed by mineralogists, except in a few instances. According to Werner's system, it must chiefly belong to the transitive, and the floetz or horizontal rocks. Some few examples have been already mentioned of very compact ancient marbles, with a fine fracture like the argillaceous substances, such as the *palombino*, and that which resembles ivory. That called Greek, and the ancient black and yellow, also approach to this division.

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* Molina, St. Nat. p. 77.

† Spafford's General Geography, Hudson 1809, 8vo. p. 190.

Many of the marbles used in the Egyptian monuments appear to be of this description, and Wad has divided them into two kinds, the *densum*, and the *lamellosum granulare*. Of the former are snow white, and yellowish white, reddish and yellowish grey, and Isabella yellow, passing to yellowish brown*. He adds that the *lapis Troicus*, of which, according to Strabo, the pyramids were chiefly built, must belong to this sort, as Niebuhr says they are constructed of limestone full of porpites, or nummulites, drawn from the mountains called Mokattam, but anciently *Mons Troicus*. But, according to many specimens and recent observations, the pyramids are built of a beautiful fine limestone, which often contains shells. M. Rozière, an excellent judge, in the abstract of Egyptian mineralogy, which he presented to me, regards the two long chains of mountains, which confine on either side the long valley called Egypt, as being both of a calcareous nature, the sandstone only beginning about twenty leagues from the cataracts, a little above the town of Esneh. The celebrated tombs excavated at Thebes must of course be in limestone. Ancient.

Among the modern marbles, the most compact are those referable to the marlites, as being com- Modern.

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* The African red is often compact.

bined with a considerable quantity of argil. The others have seldom attracted especial observation; and the division indeed cannot be regarded as of much importance, as even in geology the granular marbles cannot always be regarded as primitive, nor the earthy as secondary.

Most of the compact marbles also contain shells, so that they belong to the next subdivision.

STRUCTURE III. CONCHITIC.

Of Bleyberg. The most beautiful and celebrated of this kind is a recent discovery, being found at Bleyberg in Carinthia, where it appeared in a bed of common limestone, above a vein of lead. It is unfortunately brittle, so that pieces of a large size cannot be obtained. It is a grey marble, or fine limestone, reflecting the red, green, and blue tints of the opal, and almost with equal fire. These exquisite colours arise from the laminar naker, or what is commonly called mother-of-pearl, of a kind of nautilus, of which fragments are imbedded in this splendid substance; their lustre being probably heightened by the fine reflections of iron, observable in that of Elba, for veins of elegant pyrites are not unusual in this stone.

The name of Lumachella, which in Italian simply implies snail or shell marble, now begins to be confined to this, and the following elegant kind.

Lumachella.

Among the numerous marbles discovered in the ruins of Rome, is said to be the beautiful lumachella, ridiculously styled of Astracan, a name which has embarrassed Patrin, who discovered none such in the regions around that city, so celebrated in the Orlando Furioso, and the romances of the middle ages. If he had looked into Ferber or Born, he would have seen that it is a mere corruption, owing to the omission of one letter, the Italian being *Castracana*, not *Astracana*. One kind, according to Born, is called *castracana della castellina*. This is of a yellowish white, spotted with little grey dots*.

The finest lumachella, reputed ancient, is of a deep brown colour, and contains a number of shells, which form little circles, or semicircles, of a bright golden colour, or orange yellow, which appear with the greater lustre from the contrast of the base. This may be regarded as the most singular of all the marbles. Ferber also mentions the following varieties:

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* This Castracan is the Castravan of Woodward and Da Costa: the Khesroan of d'Anville. The mountains of Castravan extend behind Tripoli in Syria. See Pococke, ii. 92; and Maundrel's Travels. They are also famous for a marlite slate, with impressions of fish and sea-stars: Mode VII.

Greyish brown, with white transparent veins, like agate.

The same, with rose-coloured stripes.

Brownish yellow, with small black shells.

With regard to the inferior kinds of conchitic marble, they seem to have been little regarded by the ancients. The masters of the world, whether seated at Rome or Constantinople, continued for ten or twelve centuries their preference of the Phrygian, with crimson or lilac flowers; the imperial red of Africa; the green of Laconia; and the yellow of Numidia. Among the capital colours, a blue alone was wanting; but it is also unknown to us, and perhaps to nature, lazulite, the sole rock of that colour, being only found in detached masses; a circumstance as unaccountable as that there should be only one shrub with a blue flower, and that in our climate confined to the hothouse.

The artists and dealers at Rome, sometimes with a view of distinction, and sometimes to increase the price, may apply the name of antique as jewellers do that of oriental, merely to the more precious kinds. Such perhaps may be that marble reputed ancient, and commonly styled at Rome *Panno di morto*, or the funereal pall. It is of the deepest black, sprinkled with white shells like snails, each an inch or more in length, at

Panno di morto.

distant and rather regular intervals. It is very scarce, and deservedly in high esteem. The ancient *occhio di pavone*, or peacock's tail, is by some called a conchitic marble, the shells forming large circular and semicircular spots, red, white, and yellow*.

In the modern kingdoms of Europe, as inferior in taste as in power to the Romans, many kinds of conchitic marble have been introduced into architecture. The pillars of the venerable cathedral of Durham, a monument of the eleventh century, are constructed of a black marble with white shells, but both of a dull lustre, the quarries of which are still known to exist at no great distance. Of the black shell marble there are also tombs in the abbey of Melrose, probably from the same quarry with those of Durham. The marble of the north of Scotland is chiefly primitive.

English.

A fine black marble, with white shells, is found near Bristol, where it is used for chimney-pieces. A similar, it is believed, occurs in Derbyshire.

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* Da Costa, p. 213, says the peacock's eye is a beautiful marble, of a bright cinnabar colour, with spots and veins of milk white spar: many of the spots form circles about the size of a sixpence, filled with a red ground; and which, from an imaginary resemblance, have conferred the name. It takes a high polish, but is generally much cracked or flawed. It must not be confounded with the *pavonazzo*, or *purple*.

Purbeck boasts a marble, of which the shells form grey, blue, and white circles.

But the marble chiefly used in our ancient cathedrals and churches, was that of Petworth in Sussex, which is thus described by Woodward:

Petworth.

"*Marble*, from *Petworth, Sussex*. The ground grey, with a cast of green. 'Tis very thick set in all parts of it with shells, chiefly turbinated. Some of them seem to be of that sort of river shell that Dr. Lister, *Hist. Cochlear. Angl.* p. 133, calls *cochlea maxima, fusca sive nigricans, fasciata*. Several of the shells are filled with a white spar, which variegates and adds to the beauty of the stone. That spar was cast in the shell before this was reposited in the mass of *marble*, as is demonstrable from a view of this and other like masses. *Conf. Nat. Hist. of the Earth, part* IV. *consect* 2, *p.* 181, *et seqq. second Edit.* This is of about the hardness of the white Genoese marble.

"The slender round scapi of the pillars of the *Abbey Church* in Westminster, and of the *Temple Church*, are of this sort of marble. So likewise are those of the Cathedral Church of *Salisbury*, as I remember; and my Lord Pembroke assures me positively they are. Some persons that are less skilful in these matters, fancy these *scapi*, that occur in most of the larger *Gothick* buildings of England, are artificial; and will have it, that they are a kind of fusil *marble*, cast in cylindrick moulds. Any one, who shall confer the grain of the *marble* of those pillars, the spar, and the shells in it, with those of this *marble* got in Sussex, will soon discern how little ground there is for this opinion: and yet it has prevailed very generally. I met with several instances of it as I travelled through England; and had frequent opportunities of showing those who asserted these pillars to be factitious, stone of the very same sort with that they were composed of, in the neighbouring quarries. Camden[*] had entertained the same notion of those vast stones of Stone-Henge; but is fully refuted by *Inigo Jones*[†]." [‡]

Da Costa mentions a black coralic marble, from Wales, with madrepores an inch or two in length, like half a crown when cut across. It is, he says, very beautiful, and the tomb of Sir Thomas Gresham, in the church of Great St. Helen's, is formed of it. He confounds it with the Kilkenny marble, which he says is much used in Lon-

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"[*] In his Britannia, p. 95.

"[†] Stone-Henge restored, p. 33."

[‡] Woodward's English Fossils, i. 20. The marble of Bethersden in Kent was also noted.

don, and which contains white sparry casts of shells, both turbinated and bivalve[*].

The Derbyshire marble, of a pale ash colour, full of entrochi, was much used in London for tables and chimney-pieces[†].

Good marble is found in the side of Bowfell, in the West Riding of Yorkshire, being grey, with entrochites: it is manufactured at Kendal, and is in great demand at Manchester and Liverpool. Bowfell is one of the highest mountains in England, and sends waters into both seas. It is about thirty miles in circuit[‡].

French. France abounds in conchitic marbles. The red of Givet, containing entrochi, rather belongs to the Zoophytic structure. The department of Aube shows a grey marble, almost formed of little shells, and some large ammonites. Red, with white circles, being transverse sections of shells, from the neighbourhood of Brest. The white spots in the beautiful red *griotte* sometimes wear a shelly aspect[§]. The greyish brown of Langres. Deep black, with white belemnites, from Narbonne. The black marbles of Flanders. The pearl grey of Nonette in Auvergne, in which the screw-shells are changed into silex, but easily polished.

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[*] That supposed from Wales is in fact the same with that of Durham, as appears from Gresham's tomb.

[†] Da Costa, p. 232, &c.

[‡] Parkinson, Organic Remains, vol. ii.

[§] Brard says that the red spots on the griotte are shells, of which the outline is marked in black, p. 369: this is from the department of Herault.

Italy. In Italy, some churches of Lucca, Pisa, and Florence, are decorated with a brick red marble, containing white ammonites. The modern *ochio di pavone*, or peacock's tail, presents round spots, whitish, bluish, or red, being shells cut across. There is also a very pale yellow, with small shells, changed into white transparent spar.

Spain. Spain offers the conchitic marble of Grenada and Cordova, of a deep red with white shells; and that of Biscay, of a deep black, with shells of a splendid white. The pale yellow of Portugal, as already mentioned, presents marine bodies.

Germany, &c. The marbles of Swisserland, Germany, and the northern regions, often belong to this description; but if there were not some striking singularity, it would be unnecessary to enter much into the specification. Those of Basel have astroites and coralites; of Brunswick, Franconia, &c. belemnites, ammonites, and cochlites; of Sweden, orthoceratites.

STRUCTURE IV. ZOOPHYTIC.

Of this the ancients appear to have made no use, though it sometimes presents varieties at once uncommon and beautiful. A fine kind; easily had of the marble-cutters at Paris, is of a chocolate brown, with white madrepores of all sizes and descriptions, beautifully variegated with grey and red. This is the celebrated marble of Caen, in Normandy, which may be called the madrepore marble by way of eminence, and of which beautiful tables and other ornaments abound in that capital; even those of the traiteur, in the garden of the Tuilleries, being of exquisite elegance and variety.

Of Caen.

" The marble of Caen is of a dull red, and it has large veins or branches of a grey or white colour, which are solely composed of madrepores, distinctly perceptible, either in the form of stars, or that of diverging branches. This is then by excellence a madrepore marble.

" Its quarries are in the neighbourhood of Caen, and although it be rather coarse and common, it is much used at Paris, either for the tops of commodes, or for chimney-pieces, &c. There are tables of it in most of the coffee-houses of Paris; and it is known in commerce by the name of Caen marble. It somewhat resembles that of Languedoc; but is more cloudy, and less lively in its colour, and does not take near so fine a polish."*

Another singular zoophytic marble occurs in France, the ground being a wine red, with spots of dull white and green; the latter being itself calcareous, which is far from common. It is interspersed with fragments of madrepores, and other zoophytes, of a delicate bright red. It is probably from the south of France.

The deep red marble of Givet, with light veins or spots, contains white fragments of entrochi. That of Charlemont is veined with white and red, with white spots of madrepore.

St. Baume.

The beautiful marble of Languedoc, or St. Baume, is of a fiery red, mingled with white and grey, disposed in convolved zones. Some say that the white and grey parts are formed by madrepores. The eight columns which decorate the new triumphal arch, in the Carrousel at Paris, are of this marble, which is one of the finest of France.

The grey marble of Mons contains entrochi. It is properly an orsten, as on friction it yields a nauseous smell. The department of Calais furnishes a deep red marble, with grey spots, of zoophytic remains. The marble of St. Anne, in the neighbourhood of Namur, on a deep grey base, presents white zoophytic spots: that of Thilaire is similar; and that of Leff is pale red, with white fragments of madrepores.

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* Brard, 362. That of Canne, here alluded to, is a *griotte* of a deep red, spotted with white, according to Patrin.

The starry marble of Italy is light grey or white, and seems to be entirely composed of zoophytic fragments.

Swiss. At Roche, a league beyond Aigle, is a quarry of a handsome marble, veined with red, white, grey, and black. It is polished on the spot, and is much used at Geneva, and the Pays de Vaud; nor is it unknown even at Lyons. Polished tables of this marble present beautiful madrepores, and some shells, chiefly pectenites; but they have assumed the nature and grain of the marble, and the shell seldom or never appears in its original form *.

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* Sauss. 1092.

MODE II. KONITE.

Distinction. There is a stone universally employed in architecture, and which may be regarded as intermediate between marble and limestone. It appears to have been the *freestone* of the middle ages, called *ashler* when only roughly hewn; and is also the freestone of Woodward, and many other writers of mineralogy. Mr. Parkinson has recently confirmed the justice of this appellation, by informing us that "freestone is a compact limestone, of an earthy fracture."

Freestone.

Yet many late writers have inaccurately applied the term *freestone* to a very different substance, using it as synonymous with *sandstone*, chiefly indeed with a calcareous cement; though it has also been extended to the argillaceous, and even to the siliceous. The reason given for the name is, that such a stone may be worked in any direction; nay, Doctor Kidd informs us "that sandstones which yield readily to the chisel, and hence called siliceous freestones, are used in masonry." If the term were thus extended, it might also be applied to granite, which is used in many countries for the commonest habitations. Even calcareous sandstone can scarcely be called a freestone, as it often requires to be placed in the original direction of its layers in the quarry, else it will moulder in the air; which is also the case with some limestones employed in the public buildings at Oxford, and which therefore can scarcely be called freestones.

The freemasons of the middle ages, who appear to have been the successors of the Knights Templars, from their allusions to the temple, the military tinge of their mysterious rites, which formerly excited the jealousy and revenge of monarchs, and other circumstances, appear to have applied the name freestone from a yet more delicate and appropriate circumstance, namely, that it might be wrought into ornaments of the most minute description, such as are observable in the cathedrals and other public buildings, not to mention the crosses, tombs, and other monuments, of the middle ages, which could never be imitated in any sandstone. The little fleurets, and other miniatures, which we admire in the tombs and buildings of that period, are sculptured on a stone of the finest grain, and at the same time of a softness most easily obedient to the chisel; qualities which, if found in any sandstone, it would soon moulder, and the labours of the sculptor would scarcely survive his own century*.

Name.

The original acceptation of the term being thus lost, it has of course become vague, and ought, as in many other instances in the progress of mineralogy, to be exchanged for another, strictly appropriated, and which cannot be abused. As this rock may be regarded as the noblest of the common limestones, and though Greek etymons have become universal in the science, yet the Greek words representing limestone and silex have not hitherto been admitted, the appellation of Konite is proposed from *Κονια*, which is used repeatedly for lime by Theophrastus, especially in the last chapter of his book on stones†.

Characters.

Konite being merely a compact limestone, of an earthy fracture, sometimes coarse and sometimes finer, for its other characters those of limestone may be consulted. There is sometimes a slight admixture of silex, often of argil, rarely of magnesia, which however has been found by chemical analysis in some kinds, as those employed in Westminster Abbey and the Cathedral of York; and that fine earth must of course impart some of its usual qualities, of unctuous softness and durability*. By some little research it might probably be discovered from what quarries the stone used in our cathedrals, and other ancient buildings, was procured. One kind was

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* Calcareous sandstone of course leaves much sand in the nitrous acid; while konite produces none, or, in some kinds, a very small quantity.

† It might also be called *Oikite*, from its use in building. *Τιτανος*, another term for lime, has been oddly applied to *titan*, a metal.

Of Caen.

even brought from Caen in Normandy, merely, as would seem, because it was known to the Norman conquerors. It is said to appear in the posts and lintels of the castle at Rochester, and in many other places; but the name of Caen stone is often erroneously applied, as for instance in the abbey of St. Alban's; while we know, from authentic records, that the stone chiefly

Tottenhoe.

employed was from the quarries of Tottenhoe, in Bedfordshire. Not contented with the majestic appearance of konite, or genuine freestone, on whose soft tinge of brownish white the eye reposes with more pleasure than on the glittering splendour of marble, our ancestors increased the magnificence with single or grouped pillars of Petworth marble, drawn from quarries now unknown, near the town of that name in Sussex. This marble is often ignorantly called Purbeck, while it is totally different both in colours and composition. The structure of the

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* See the Mode Magnesian Limestone, Domain IV.

Petworth marble is even singular, as the shells, which are very small, seem changed as it were into drops of spar and marble; and the prevailing tints are a faint green and reddish brown; while in the Purbeck the tints are a bluish grey or ash, and a dull yellow or fawn colour; and the shells are marked by little black lines. These pillars of Petworth marble adorn the cathedrals of Canterbury and Salisbury, the Abbey Church of Westminster, and that of St. Alban's; not to mention the Temple church, and Great St. Helen's, in London; and probably many others might be noted. The contrast of this beautiful marble with the konite of the rest of the edifice must have been striking and magnificent; but at present all is equally covered with a white or yellowish wash, so as to recall the memory of the whited sepulchre, applied in scripture to a hypocrite; while the walls ought only to be cleaned, and the pillars polished anew, as in some sacred edifices of the Continent.

Portland stone.

At present the most remarkable konite used in the southern parts of England is that of Portland, which is thus described by Dr. Woodward:

" *Stone* out of the great quarry of *Portland*, of a pale or whitish colour, composed of numerous small roundish grains, not unlike the smaller ova of fishes. They split in the cutting of the stone; so that it is capable of being brought to a surface, very smooth and equal. Besides, this and all like sorts of stone that are composed of granules, will cut and rive in any direction: as well in a perpendicular, or in a diagonal, as horizontally and parallel to the site of the strata. 'Tis for this reason that they have obtained the name of *freestone*. Then these bear the injuries of the weather equally and indifferently in all positions: whereas all the stone that is slaty, with a texture long, and parallel to the site of the stratum, will split only lengthways, or horizontally; and if placed in any other position, 'tis apt to give way, start, and burst, when any considerable weight is laid upon it. Which inconvenience the Portland stone being not liable to, cutting freely, and being of a colour very good and agreeable, 'tis made use of for the better buildings and works about London."*

Da Costa calls the Portland stone an alkaline sandstone; and, with equal error, adds that sandstones have obtained the name of freestones because they were cut in any direction. He subjoins some account of the Surry stone of

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* Woodward's English Fossils, 1729, i. 17.

Ryegate, and Godstone; which last is said to have received its name because it was often used in churches. They seem by his account to be coarse sandstones with mica, now chiefly used for ovens and hearths, and the like purposes.

Other kinds.

Konite is by the French called *pierre de taille*, *moellon*, &c. The Italian *macigno* seems an argillaceous limestone with a little mica; while the *travertino* used in the ancient and modern edifices of Rome strictly belongs to the calcareous tufas, under which it will be described. The building stone chiefly used at Edinburgh, especially in the beautiful new city, is from the quarry of Craigleith, and is said to be an argillaceous limestone, perhaps sandstone, with blackish veins. The ancient Romans, whose buildings are alike distinguished by magnificence and durability, chiefly, like their successors, employed the *travertino*, which abounds on the banks of the river Anio, and is reproduced by its depositions. To the lasting nature of this stone, and of the mortar mixed with puzzolana, which also abounds in the neighbourhood, that is, to circumstances merely accidental, may the preservation of the common sewers, and other works of surprising antiquity, be ascribed. But the use of konite in building ascends even to the earliest ages, the pyramids of Egypt being constructed

Pyramids.

with this material; which, as already mentioned, seems the *lapis Troicus* of the ancients. The Egyptian konite, which forms a whole chain of mountains, extending from Cairo and the front of the pyramids, far to the south, is sometimes simple, and sometimes contains shells, chiefly nummulites, which, when cut across, resemble grains of wheat or barley; whence the fable of the ancients, that the workmen employed received such vast quantities of grain, that much of it was left and petrified. Some of the most ancient edifices of Persia, Greece, and Italy, are also built with konite; but the ruins of Poestum, and the temple of Agrigentum, are of calcareous tufa.

In general, writers on mineralogy, while they are often occupied with laborious trifles, seem strangers to the chief object, which is the utility of the substances. Brongniart, the director of the porcelain manufacture at Sevres, and accustomed to consider objects as adapted to the purposes of human life and manners, has sometimes *deviated* into utility; and his account of the konite thus becomes interesting.

Brongniart's account.

"This substance is the *chaux carbonatée grossiere* of Haüy, and is commonly called *pierre à bâtir, pierre de taille,* and *moellon.* The texture is often loose, and the grain coarse. It is easily cut with any sharp instrument, but does not receive any polish. The fracture is granular and dull; as are also the colours, which are white, grey, and Isabella yellow. The kinds differ greatly in the fineness of their grain, in colours, and duration; but these differences only influence their use for distinct purposes, and do not depend upon their original positions.

"Some have a very fine grain, and a whitish colour; but have little hardness, and cannot be employed except in sculpture. Such are the stone of Tonnerre, in the department of Yonne; and one of those quarried at Nanterre, near Paris; not to mention other examples.

"Others have a coarser grain, while their colour is yellowish; and they are tender and friable. Such are the stone of Conflans Ste. Honorine, near Paris, of which the beds are sometimes two yards in thickness; and that of St. Leu and Trossy, in the department of Oise; the beds of the latter being only a yard thick.

"In fine, others, though of a very loose texture, and of a very coarse and visible grain, although even composed of calcareous sand and agglutinated fragments of shells, &c. possess nevertheless great hardness and solidity; such as the stone of Saillancourt, near Pontoise, the beds of which are so thick that the quarry seems cut into one mass. It is reserved for bridges and highways*.

"This rock seems exclusively to belong to the depositions of coarse sediment, which are far from the primitive mountains, and which approach the alluvial territory. Although it present beds of great thickness and extent, it never forms mountains, but only round hills, of which the skirts sometimes display pretty high precipices. It forms the base of many plains, such as in France the plains to the south of Paris, those in the neighbourhood of Caen, and others.

"The beds of this rock are very distinct, being horizontal, rarely inclined, never convoluted nor bent, and commonly divided by clay, marl, or sand. There are sometimes seen, between them, infiltrated geods of quartz and calcareous spar, as at Neuilly, near Paris; or thin layers of keralite or flint, interspersed with shells, as at St. Cloud and Sevres.

"These beds vary much in thickness; and it may be observed, that they are thicker in the soft kinds than in the hard. The latter is often in such thin layers that it is used in some countries, as in the Cote d'Or, near Dijon, instead of slates, to cover the houses; and these flat stones have received the absurd name of *lava*. This limestone is often an impure mixture of calcareous sand and fragments of shells; and sometimes contains entire shells, which are generally of the kind called *littoral*, because they are found near the shores of the sea[*]. The limestone of the neighbourhood of Paris is full of great numbers of these shells, called *cerites*, or screws, which are sometimes so abundant, that the stone seems entirely formed of them. There is found at Weissenau, near Mentz, a bed of limestone, which is entirely composed of little *limnés*[†], of the size of a grain of millet seed.

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* One stone in the parapet of the celebrated bridge of Neuilly is thirty-four feet in length. P.

"There are neither veins nor beds of metals in this limestone, which only contains oxyd of iron, either argillaceous or calcareous, in beds or in heaps; it is also said that carbonate of zinc has been found in it; but of this there is no proof. Coal is never found in this kind of limestone; even silex is rare; and sulphurets of iron are excluded.

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[*] It may be observed in the catacombs under the city of Paris, that the shells form layers between the beds, like flint in chalk: so that the depositions must have been at successive periods. P.

[†] The Linnæan name is wanting.

"But if the differences between the compact and this kind are of little consequence, the geological differences are numerous and important.

"This limestone is employed in architecture; the solidity of some of its varieties, and the ease with which it is wrought, giving it great advantages. It is called *pierre de taille* when it is in large masses, and *moëllon* when they do not exceed four cubic feet.

"It is unequally dispersed, being rare in England, and common in France, especially in the environs of Paris, chiefly to the south of that city, from Sevres to Gentilly. Its beds, which are horizontal, extensive, thick, and continuous, are situated between chalk, which it covers, as may be observed at Meudon, and gypsum, which covers it in some parts. It is separated from the chalk by a bed of bluish potters' clay. To different parts of its beds distinct names have been applied, according to their quality, and the uses for which they are destined. That which is of a fine grain and compact texture is called *pierre de liais**: it may be cut in sharp squares, and resists the weather; the thickness of its beds seldom exceeds eight inches. The

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* In the common dictionaries, *liais*, and *pierre de taille*, are translated *freestone*. Sandstone is *grès*.

pierre de roche is as hard as the *liais*, but porous and full of shells; thickness of the beds about two feet. The *lambourde* is a tender stone with a coarse grain; the beds being about three feet. These three qualities, and others which we omit, are often found in the same quarry.

"The quarries which furnish the best building stone used at Paris, are those of St. Nom in the park of Versailles; La Chaussée, near St. Germain en Laye; Poissy; Nanterre; the three last yielding stones almost as beautiful as the *liais*; of Saillancourt, near Pontoise; of Conflans Ste. Honorine; this quarry yields the finest tender stones, sometimes seven or eight feet in thickness; of St. Nicolas, near Senlis, which is a *liais*; of St. Leu and Trossy, department of Oise, which is a soft stone.

"The soft kinds are sawed dry, the saw having teeth as that used for timber. The hard kinds are divided by a saw without teeth, by the means of water and pounded sandstone. But that they may not decompose in the air, they must be placed according to their original beds, for very few will last in the opposite position. Several porous and tender kinds are subject to split by frost. The weight varies according to their quality; thus the hard stone of

Meudon is to the tender stone of St. Leu as 24 to 17. This stone being generally impure yields a bad lime."*

This important rock may be divided into two structures; the simple or entire, and that mingled with shells, or the Conchitic. No example of the Zoophytic seems to occur in this kind of limestone, which is of recent formation.

STRUCTURE I. ENTIRE.

Aspect 1. Fine-grained. From Egypt.

From Caen, Tonnerre, and Nanterre, France.

From Tottenhoe, Bedfordshire.

From Portland.

Aspect 2. Coarse. This is often found in the same quarries.

From Saillancourt, near Pontoise, in France.

From Portland.

From Scotland.

Yellow, from Lyons, the chief building stone there used.

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* Brongniart, i. 204.

STRUCTURE II. CONCHITIC.

Aspect 1. With nummulites, from Egypt.

With cerites, from Paris.

With various shells, from the vicinity of Bath.

The *pierre de taille* used at Marseilles is a conchitic limestone, of which the quarries are at Cape Couronne*.

MODE III. LIMESTONE.

Carbonates of lime.

The characters of this rock will be given in some distinct Structures. The combination, as of the former Modes, is chiefly lime and carbonic acid, about 40 of the latter to 50 of the former; whence the term carbonates of lime. But the Modes differ in minute particulars, as already mentioned.

This useful rock abounds in most countries. It is generally burnt to make lime and mortar; but is also employed in building, and sometimes in making roads, though the siliceous substances be more durable and proper for the latter purpose.

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* Sauss. § 1517.

Geologic relations. It is often full of marine shells, and lies superincumbent upon slate or sandstone: some have even confounded compact limestone with sandstone. Patrin has observed that the calcareous deposition was more abundant on the summit of mountains than on their sides, because the slopes scarcely received, on a hundred fathoms of surface, the same quantity with ten fathoms of the level summit*. Hence the latter is sometimes insulated and separated from that of the plains, because the thin beds on the sides of the mountains were worn down by the waters; and as the summits of the mountains attract clouds, so under the primeval waters they must have attracted the various substances contained in them.

The calcareous chain of the Pyrenees is far higher than the granitic, containing marine shells, and sometimes assuming the combination called orsten, or swine-stone, a sort of coarse fetid marble. Such is the summit of Mont Perdu, a calcareous colossus, about twenty miles in length, and four or five miles in breadth, with an elevation of 10,500 feet above the level of the sea.

Bricias. Sometimes the calcareous beds on the steep slopes have rolled down, and the broken fragments have afterwards been united into bricias, which are very common in this kind of rock.

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* Min. iii. 16.

Contorted.

In a softer state these beds have been convolved, in various contrasted forms. "Saussure cites many examples of these heaps of calcareous beds, which are contorted in such a manner as evidently to show that they have been bent by the effect of the force which parts of the same beds, in a higher situation, have exerted against them.

"Among others, he observed this effect in three different places, on the borders of the lake of Lucerne. The one near the mouth of the Reuss: 'The bent beds,' says he, 'are of a grey compact limestone; they rise from the lake in a vertical position; they then bend towards the south-west, and on that side become concave. To the north-east, on the side of their convexity, a hollow presents itself.

'On closely examining these beds, they are found to be very much broken, and appear to have been so in the act of bending, and even by the force that bent them.'

"The second place is half a league to the northward of the preceding, likewise on the border of the lake of Lucerne, on which Saussure sailed: it is a mountain called Axenberg. 'From the summit to the foot of this calcareous mountain beds are observed in the form of an S, compressed, or of which the bendings are very strongly marked. These S's are often repeated, sometimes in contrary directions, and masses of rocks are found between them, whose stratifications are not distinct. When these contorted beds are closely observed, it is found that they are often broken in the strong curvatures; and this proves that they were not formed in that position.'

"The third place is opposite the preceding, on the other side of the lake: 'It is a mountain in which the beds, which are nearly horizontal below, turn up above and form a C, whose concavity looks to the N. N.E.: on the left, or to the S. S.W. of the C, there is a large hollow; and what is most remarkable is, that the beds which adjoin the lower branch of the C extend themselves to a great distance, forming a mountain with regular and horizontal beds.'

"From these facts Saussure concludes that these dislocations of beds are produced by a *refoulement*, or repressure, which has folded them over each other."*

Calcareous rocks seem to be comparatively rare in Africa, and even in Asia. As layers of flint are found in chalk, so layers of chert, or keralite, appear in limestone; while Lydian stone, and siliceous schistus, sometimes intersect the primitive calcareous rock.

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* Patrin iii. 19.

Limestone often presents mural precipices, as in the Pyrenees, and sometimes in forms approaching the artificial, as in the circus, towers, and cylinder of Marbois. The picturesque appearances of Chedder cliffs are on a smaller scale. In the chain of Jura, and in the Pyrenees, calcareous mountains have been observed, with exterior arrects of 40 or 45 degrees, while the interior become more and more vertical. Palassou and Pasumot, in their descriptions of the Pyrenees, have observed a mountain of limestone, formed of oval and circular concentric layers, which present a most singular appearance. On a smaller scale, as in pisolites and sinapites, limestone often affects the orbicular form.

Saussure informs us, § 347, that the chain of Jura is calcareous, with the exception of some few spots, covered with calcareous sandstone. In § 1937 he remarks contorted beds of compact limestone, which he says of course must be sedimental, not crystallised, and must have been deranged by a *refoulement*. Nor has the remarkable intermixture of compact limestone with granular, escaped this great observer[*].

The singular rock which contains pholades, or sea-dates, is a blackish argillaceous limestone, rather of a soft consistence[†].

Primitive. That granular limestone is primitive has been long allowed. Among many other remarkable mountains of this stone, the stupendous heights of Finster Aar Horn, Yungfrau Horn, and Shreck Horn, or the Peak of Horror, in Swisserland, deserve especial commemoration. Saussure has long since observed, that it often presents lofty spires, like granite; and being a manifest deposition, must evince that granite is so likewise. It appears between layers of mica slate and gneiss, as schistose siderite; and alternates with common slate. Primitive limestone is commonly white, dark iron grey, or reddish brown, and is not always granular, being sometimes compact. It sometimes supplies the place of quartz in mica slate, and sometimes of felspar in granitoid, and a rock of the gneiss structure. It is rarely metalliferous, but in Siberia it presents rich mines of copper, and in South America veins of gold and silver. It is remarkable, that in limestone the shells retain their original form, while in clay slate they are compressed; a circumstance ascribed to the great subsidence of the latter. Caverns are seldom found except in limestone, the rock being commonly eroded by a stream of water.

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[*] Sauss. 2226.

[†] Id. 1356. On the coast of Aunis, near Rochelle, little oysters called *gryphites* are forced into the mud by the sea. The whole soon becomes a hard stone, and is called the shell-stone of Aunis. Mem. Acad. de Rochelle, tome iii.

Formations.

The Wernerians regard limestone as of three formations; the primary, the transitive, and the floetz, flat or horizontal. The second often contains coralites and madrepores; but Faujas showed a madrepore in Carrara marble, which is esteemed primitive.

Limestone seldom or never occurs pure, there being generally a small admixture of argil, sometimes of silex, sometimes of iron. When there is manganese it forms a more tenacious mortar.

STRUCTURE I. GRANULAR.

Aspect 1. Common. The characters mostly correspond with those of marble; but the mode of combination must vary, as it is not capable of so fine a polish.

The colours are white, grey, black, reddish, and yellowish. A green tint may be suspected to indicate magnesia.

Granular limestone often belongs to the noble kinds or marbles; it is also often found more soft, light, and coarse, when it falls into this division.

Grey granular limestone, with calcareous spar, from Lusatia.

The same, mixed with slate, from Saxony.

Reddish brown granular limestone, with slate, from the same.

White granular limestone, from Stiria.

Chinese tablets.

White sparry limestone, in thin shining spangles, from China. "There are brought from China," says Born, "tablets of an oblong square form, often marked with Chinese letters; of a dull polish, and sold as artificial, under the name of rice stones, being regarded as composed of rice reduced to a paste; but the external characters and chemical analysis demonstrate that it is only a sparry limestone, cut in these forms." A like fabulous idea concerning rice has been entertained with regard to iconite.

Argillaceous limestone, which naturally splits into lentiles, convex on both sides, which might seem to be a bricia were not the paste absolutely homogenous. Sauss. § 1377.

A limestone, containing large shells full of sand. Sauss. § 284.

Aspect 2. Micaceous. Primitive granular limestone is often interspersed with mica, and sometimes with orbicular crystals of quartz. It has already been observed, that the mere mixture of mica can never be understood to alter the denomination of the stone.

Micaceous limestone, from the Alps.

The same, from the Grampian mountains, in Scotland.

The substance called Cipoline marble is often so coarse as rather to belong to this division.

Limestone, with nodules of mica and of sand, from the Pyrenees.

A micaceous limestone, in which the mica is so abundant that the calcareous mixture is scarcely distinguishable. Sauss. § 1811.

STRUCTURE II. COMPACT.

Texture, compact, generally massive and earthy, sometimes schistose. Characters.

Hardness, from the gypsic to the marmoric. Fracture, fine scaly, sometimes large and flat conchoidal, sometimes uneven. Fragments, amorphous, rather sharp.

Lustre, dull. Opake; but often translucent on the edges.

The most common colour is grey, of various tints, and yellow of different shades. It is often veined and spotted in various forms.

Primitive compact limestone, from the Alps.

The same, from the Grampian mountains, Scotland.

Primitive limestone, with garnets, from the Pyrenees.

Grey compact limestone, intersected with granular, from the Alps.

Black compact limestone, intersected with chert, from Derbyshire.

The same, with spots of bitumen. The black colour often arises from the bitumen, as appears from the stones becoming white when calcined.

Limestone, of a dull white colour, from Port Rush, in the north of Ireland. This stone, which has sometimes been called chalk, supports the celebrated basaltic columns around the Giants' Causey. It abounds with fossile remains, and nodules of dark flint: for the depth of sixty feet under the basaltin it is impregnated in a singular manner with small particles, mostly oval, of the basaltin; and, from the mixture of colour, is vulgarly called *mulatto* stone. A most singular geological fact.

Mr. Kirwan mentions a sky-blue limestone, from Aberthaw, in Glamorganshire. But this, like the blue marble of Narbonne, or the blue turquin, appears to be only grey. Dr. Kidd describes it as light blue, or grey; and says, that it is common in Somersetshire, and that it only occurs in the form of shingle, or large pebbles, on the sea shore at Aberthaw. This colour seems to indicate a mixture of iron; and such limestones, when calcined, become of a buff colour, and furnish a harder mortar than any other.

STRUCTURE III. CONCHITIC.

Many of this description belong to the noble division, or marbles, not to mention the konites; but many also are of a soft and coarse nature, whence they fall under this Structure. The limestone containing shells is generally grey, but sometimes dull white, or brown. Sometimes even bones are found in limestone, and in marble; and Faujas, as already stated, has recently observed a remarkable example near Verona, where a fine black marble, containing petrified bones, is worked into large columns. Karsten, as quoted by Gmelin, has also mentioned a limestone, containing bones, which is found at Erfurt; but the pieces seem to be small and detached.

Shells. To enumerate all the shells contained in limestone would be infinite; nor have such as occur in rocks been hitherto carefully distinguished from such as are found detached and scattered. It will be sufficient for the present purpose to mention such as are generally inherent in large masses of limestone, konite, or marble; thus forming, as it were, a constituent part of these rocks. This subject will be further illustrated by the plates.

It has been observed as unaccountable, that the shells of those fish which are called Pelasgic or Oceanic, as inhabiting the unfathomable depths of the ocean, are often found at the greatest elevations; while those which approach the less profound depths, and even the shores, are rather found on the skirts and lower hills. If this observation be exact, the explication seems very difficult, except perhaps that, under the chaotic waters, the proper purity and temperature to support animal life could only be found at such elevations.

The shell venerated as the most ancient, and unknown in modern conchology, is that called the *Cornu Ammonis*, or horn of Jupiter Ammon, from the twisted horn, a symbol of power in the images of that deity. In the middle ages they were supposed to be petrified serpents, and sometimes fraud has cut out heads, being esteemed pious memorials of the miracles of saints. If they at all exist at present, they are said to be found microscopic in the Adriatic sea; but a contorted species of nautilus has often been confounded with *Cornu Ammonis.* The petrified are styled Ammonites, the Greek termination in this and the other shells marking their stony nature. Ammonites occur of all sizes, from half an inch in diameter, as those which form the singular Dorchester marble, to six feet, or the size of a coach-wheel, as some have been found immersed and converted into chalk at Margate.

The nummulites, or porpites, occur in the limestone of Egypt and of France, being thin shells, or rather movable opercules or covers to protect some shell-fish. Belemnites*, another embarrassing form, are generally found detached. Entrochites, or joints of the sea-star, are very common. The encrinites, other joints, resemble lilies.

To proceed to the UNIVALVE shells: nautilites abound in many limestones and marbles; and sometimes retaining their original lustre, impart singular beauty to the opaline marble of Carinthia.

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* Perhaps these may be spines of a large pelasgian sea-urchin. The porpite has at last been observed alive in the South Sea. See the curious plates to the voyage of Peron, Paris 1808, 4to.; where the rich and interesting delineations of the zoophytes and mollusks are very new and striking.

Lituite.
Orthoceratite.
Conite.
Buccinite (Trumpet).
Bullite or Globosite.
Turbinite (Screw-shell).
Dentalite.
Patellite.
Cochlite (sea-snail).

Among the BIVALVES:

Solenite (Razor-sheath).
Tellinite (Limpet).
Dionite (Venus) Dione.
Aphrodite and Hysterolite.
Chamite (Clam).
Pectenite (Scallop).
Ostracite (Oyster).
Anomite (Gryphite).
Mytelite (Muscle. Mya.).
Pinnite (Naker).

The chief MULTIVALVE shell observed in a state of petrifaction is Lepadite, or Balanite.

Several crabs, &c. are discovered apart: and a beautiful little tortoise in flint was found by my friend Mr. Knight, upon his estate of Milton, in

Cambridgeshire, being, it is believed, an unique example.

Echinites singularly abound in the chalk-pits of England, with cockles, &c.; but they are easily separated, and of course foreign to the present purpose.

Limestone, with ammonites, from Dorsetshire.

With belemnites, Thuringia. They may perhaps have been mistaken for bones.

With orthoceratites, Erfurt.

With nautilites, Upper Austria.

With strombites, Jena.

With cochlites, Norway.

With chamites, Mont Martre.

With gryphites, Alsace.

Numerous other examples might be added.

STRUCTURE IV. ZOOPHYTIC.

Zoophytes, including the mollusks, also abound in common limestone. They are of many varieties; as the turbinated, the porpite, the fungite, the astroite, &c. Among them may also be classed the milleporite, the celleporite, the entrochite, either in many or single joints, and of several varieties, the gorgonite, the coralite, and the encrinite. The trochite is a word used by some for single joints of the entrochite, which can scarcely be distinguished from those of the encrinite, rarely marked by the lily at the summit.

Limestone, with nummulites, from Egypt.

With entrochites, Derbyshire.

With madreporites, from Gothland.

Numerous other examples may be added, from all countries; exclusive of the mere calcareous petrifactions, which are found slightly adherent or apart.

STRUCTURE V. PISOLITE.

This kind is so called from its appearance, resembling conglomerated peas; and is chiefly brought from Carlsbad in Bohemia, where it constitutes a large bed. It is of a yellowish white; and the imaginary peas are in elegant concentric layers of white and brown, formed around a grain of sand, like pearls in the shell. Cronstedt has with some propriety ranked it among the sinters or depositions.

STRUCTURE VI. SINAPITE.

In this the orbicular accretions are smaller than in the former; the structure quite distinct, and more compact. The name is derived from mustard seed. Some call it *meconite*, from the seed of the poppy; while others use the term *oolite*, from the eggs or roe of fish: but as this appellation might imply that the grains equal the eggs of birds, it is ambiguous; not to add that, as the substance was really supposed to be the petrified roes of fish, whence the English roe-stone, it is better to dismiss a term leading to erroneous ideas. The analogy between pisolite and sinapite is also preferable, both being derived from the vegetable kingdom.

This substance is far more abundant than pisolite. According to Gmelin, it is frequent in the stratified mountains of Gothland, Saxony, Thuringia, Brunswick, France, Swisserland; forming ample and often repeated strata, of a dull grey or brown colour; and sometimes, though rarely, presenting animal remains.

The Ketton stone of Rutlandshire is a fine example of this kind of rock.

Sinapite, from Iceland.

The same, from Ketton.

The same, of a still finer grain, from Bath.

The same, from the various countries mentioned by Gmelin, where, as it forms vast beds, it cannot be classed among the depositions.

MODE IV. ALABASTRITE.

Ancient.

The substances called *alabastrum* and *alabastrites* by the ancients, are well known to be merely calcareous, as they effervesce with nitrous acid; whereas the moderns have applied the name of alabaster to quite a distinct substance, impregnated with the sulphuric acid, so that the nitrous can produce no effect.

The classical writers of antiquity more frequently use the word *alabastrites* than *alabastrum*; and it seems therefore far more proper to retain the former name for the ancient alabaster, than to apply it with some writers to the modern. In general it is distinguished by its yellow colour, especially mentioned by Pliny; and often by brown stripes, arising from successive depositions, with some resemblance of the layers of the onyx, whence the onyx tables and pavements of the ancients. For alabastrite is acknowledged to be a mere deposition from superincumbent rocks of marble; and, with stalactite and stalagmite, forms the *sinter* of the Germans; while alabaster is an original rock, and is even found primitive in the Alps.

Of this remarkable substance, so well known in Roman luxury, Pliny gives the following account. "Our ancestors thought that onyx was only produced in the mountains of Arabia, and in no other region; but Sudines adds Carmania*. At first only drinking vessels were made of it; but afterwards the feet of beds, and even seats. Cornelius Nepos says that it was reputed a great wonder when P. Lentulus Spinter displayed amphoræ of onyx as large as Chian casks; yet five years after he saw columns thirty-two feet in length. But from more refinement in the choice of this stone, four columns of a middling size, placed by Cornelius Balbus in his theatre, were esteemed monuments of surprising grandeur. We have seen more than thirty in the dining-hall which Callistus, well known by his power among the freemen of the emperor Claudius, had erected at great expense.

"Some have called this stone alabastrite; and of it little pots or boxes for ointments are formed, as in them it is supposed to be less liable to corrupt†. When calcined it is also used for plaster. It is produced towards Thebes in Egypt, and near Damascus in Syria; but this last is white, and little esteemed. The best is from Carmania, the next from India, and a valuable sort is also found in Syria and Asia Minor. The worst, and without any splendour, is that of Cappadocia. They are chiefly approved when of a honey-yellow, with orbicular clouds, and little translucent. It is esteemed of little value when of a horn colour, or white, or of a glassy appearance."*

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* So Brotier's edition: some read Germany.

† Hence the name, which implies what cannot be taken hold of; because, as commonly supposed, these little pots had no handles. But may it not imply the slippery smoothness of the pot or of the stone?

Nardi parvus onyx. HOR.

Pliny then mentions that the Lygdine marble

Alabastrum seems to have been more generally used in later times: *cum alabastris unguenti*, says the author of the work ascribed to Petronius Arbiter; and who has deceived all the critics, for he surely flourished about the time of Elagabalus; and his keen satire is directed against the manners, and not Nero, or any particular person. The learned reader may consider the list of presents, p. 211, edit. 1669, and may compare many other passages with the *Historiæ Augustæ Scriptores*, which form the best introduction to this strange work. See also the arguments in the preface of Hadrianides, or Hadrian de Valois, which indicates a verse taken from Statius, and refers this satire to the age of Gallienus. The *castella* for villas, used by this author, is first introduced in that sense by Apuleius.

Alabastrum is also put absolutely, by other writers, for *a box of alabaster*, commonly used to contain ointment. That poured on the feet of Jesus was in "a box of alabaster." John xii. 3, and other evangelists. It was a sacrifice of her toilette by Mary Magdalen.

* xxxvi. 12.

of Paros was next in esteem for preserving ointments; and it is probable that this name did not extend, as is supposed, to the marble of Paros in general, but was confined to stalactitic portions found in certain cavities. Though this substance be merely an infiltration from surrounding rocks, yet it sometimes fills immense caverns, so that tables may be seen in Italy, and some even in England, of eight feet by four; being entire slabs of the most beautifully veined alabastrite, commonly called by the artists oriental alabaster. The veins seem to be chiefly of a ferruginous nature. When iron is absent the substance may remain of the purest white; as the grand and singular depositions in the well-known grotto of Anti-Paros, one of the wonders of the world. But this pure white kind, being of a very soft and fragile nature, was little esteemed by the solid taste of the ancients; and is seldom used even by modern artists, except in minute and trifling ornaments. The yellow and veined kinds, on the contrary, are hardened by the presence of iron, so as to scratch marble, which may also be done by portions of the white, as the softness rather arises from the laxity of the grain, probably from the want of compression.

Modern alabastrite.

In modern times alabastrite, equal to the ancient, with brown veins, has been found in small pieces at Mont Martre, near Paris; but those of Spain are in rocky masses, and of great beauty. It is said that the territory of Volterra, in Tuscany, affords no less than twenty remarkable varieties*.

Of Volterra.

"Those most esteemed are the agate-alabasters, to which this name is given, on account of their fineness; and the onyx-alabasters, which present clear and distinct layers, of different colours, all of them undulated and festooned, with saliant and re-entering angles, like the zones of fortification-agates, and of which the whole forms a figure nearly circular. The formation of these zones is owing to a play of crystallisation, like that of agates; and in like manner they are always found exactly parallel among themselves, whatever may be the irregularity of their course. A perpetual circulation takes place in the interior of the alabaster, while it is still in its native site, which arranges the various particles of which it is composed, according to laws determined by their mutual affinities.

"The onyx-alabaster is sometimes formed in sheets on a horizontal plane; and then these layers, instead of forming re-entering courses, describe straight lines, or slightly undulated; and as these layers are of lively marked colours, such as the white and red, cameos may be made of them, as they are of onyx-agates.

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* Patrin, iii. 110. In the catalogue of Davila, ii. 98, it is observed that the ancient alabasters were probably from Spain, as the same sorts abound there.

" The onyx-alabaster of Sienna is of the utmost beauty: it presents layers of three bright and distinct colours; yellow, red, which is opake, and white, which is very transparent.

" The other alabasters of Italy, which are most valuable, are the agate-alabaster of Sienna, which is nearly transparent, and of a fine uniform yellow.

" The alabaster of Montanto, in Tuscany, which is yellow, semi-transparent, with undulated white veins.

" The alabaster called *Pecorino*, which is transparent, of a uniform fawn colour, or mingled with brown veins.

" The isle of Malta also furnishes various alabasters, and particularly one of the colour of wax, like the agate-alabaster of Sienna; its paste is of the greatest fineness, and of a beautiful semi-transparency. In the Museum of Arts is seen a statue of Minerva, nearly as large as life, of a similar alabaster, which is much admired.

" The name of oriental alabaster is given to that which adds to a fine paste lively and distinct colours, and a hardness which renders it susceptible of a fine polish. In general, the denomination of oriental stone implies less the native place of the stone, than its intrinsic value; thus in Italy and France alabasters are found which deserve the epithet of oriental.

"The celebrated sculptor Puget discovered near Marseilles an alabaster, so transparent, that the eye could penetrate into the interior of the substance; and, to the depth of two fingers, trace the beautiful tints with which it was coloured.

"Guettard says that the waters of Aix, in Provence, form a deep-brown alabaster, mingled with whitish zones, which make it resemble the oriental kind. This alabaster is found in an ancient conduit, built by the Romans, which brings the water from a spring about half a league from the town.

"This aqueduct was entirely filled by this beautiful alabaster, which presented distinct layers, of about a line in thickness. They were found by the lens to be composed of a great number of very thin plates; and the whole formed a solid compact mass, hard enough to take the finest polish.

"At Montmartre, and in the other hills of plaster-stone in the environs of Paris, and especially at Lagny, a substance is found, which at first view resembles a fine oriental alabaster: brown zones of different tints, on a lighter base, are in like manner observed in it; they are undulated, and parallel to one another, and produce a most pleasing effect. But this pretty stone is only a stalactitic gypsum, which takes but a slight polish, and much less brilliant than that of real calcareous alabaster*."

Yellow clouded alabastrite, from the ruins of Rome.

Veined alabastrite, the onyx of the ancients, from the same.

A noble column, about twenty-four feet in height, was found near the Appian way, and placed in the library of the Vatican; perhaps the same which is now in the Museum at Paris.

Veined alabastrite, white, with reddish yellow veins, from Andalusia, Spain.

Veined alabastrite, from different parts of Spain.

With mazy veins, light yellow and brown, from Malaga. This has furnished many decorations for the palace at Madrid.

Mazy alabastrite, of a deep brown, with lighter veins, from Sagena, in Sicily.

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* Patrin, ib.

With veins of a lively red, mingled with yellow ones, more or less deep, from Montreal, in Sicily.

With yellow and black veins, from Mount Pellegrino, in the same country.

Yellow, veined with white; and another, with black, brown, and white mazes, from Malta.

Fiorito. There is also a kind of alabastrite which the Italians call *fiorito*, implying that it is marked with irregular spots, faintly resembling flowers. Two columns of this kind, very rich in colours, which however he does not specify, are placed, according to Brard, in the Napoleon Museum at Paris. They were discovered, in 1780, in the ruins of Gabium, four leagues from Rome. It is probably with this kind of alabastrite that Strabo compares the Synnadic marble, when he says it is variegated like alabastrite; but perhaps he means its light aerial appearance, whence the poet of St. Sophia compares it to roses sprinkled on white air.

For the common or modern alabaster, the reader is referred to Mode X., which follows Gypsum.

MODE V. LIME-SLATE.

Distinction.

The marbles, konites, limestones, and alabastrites, are so important in many points of view, that though this kind chiefly differ in the structure from limestone, it was thought advisable to give it a distinct division, especially as the mode of combination is really different, for, not to mention the micaceous kind, it is more abundant in argil than the massive limestone. Lime-slate is the *calcareus fissilis* of Wallerius; but the foliated limestone of Werner is so called only from the fracture.

Lime-slate sometimes presents alternate layers of different colours; such as white and reddish, and white and greenish; both of which are found at Dannemora, in Sweden. It sometimes alternates with keralite or chert, sometimes with clay-slate, sometimes with marl-slate. Some singular marbles, of which the veins are quite detached, and uniform, probably belong to this division. The cipolin also sometimes, though rarely, appears in level layers, divided by foliaceous mica*.

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* The whole isle of Garbolach, Hebudes, is said to be composed of lime-slate, or what is called *marble flag*.

Saussure observed many mountains in the Alps chiefly composed of what he calls micaceous limestone, often alternating with mica slate. The following observations occur in his description of Mont Cenis, celebrated for the passage into Italy.

Mont Cenis.

" Soon after is observed the micaceous schistus, which really forms the body of the mountain, but which is also found in some places covered with tufas. These schisti contain calcareous earth, with a granular and brilliant aspect, such as it assumes in primitive mountains: it is even in such quantity that these schisti strongly effervesce with the nitrous acid; and become friable, after having remained some time in it.

" It will be seen hereafter that calcareous earth and mica are found at Mont Cenis, mingled in all proportions; from limestones nearly pure, in which only a few plates of mica are observable, to the micaceous rock, which contains little or no free calcareous earth, and in which quartz supplies the place occupied by the limestone in the former. There is nevertheless this remarkable circumstance in the schisti of Mont Cenis, that those which are calcareous are seldom found free from quartz, as is proved by the sparks that may be almost always obtained from it by steel;

and in like manner quartzose micaceous schistus is seldom found which does not yield some bubbles in acids, and which, reduced to powder, does not lose some of its weight in distilled vinegar.

"These micaceous calcareous schisti are not common. Those authors who have written systems of mineralogy have not known them, or at least have neither classed them, nor given them names in their works. I have described, in the second volume of these travels, § 996, those which I discovered in the valley of Aosta in 1778; but in them the free calcareous part is never predominant, it forms at most but the fourth part of the rock. Those of Mont Cenis differ also in the colour of the mica, which is of an iron grey, or verging to blue, while that of the valley of Aosta is white or yellowish.

"The first rocks of this kind, which are met with above Lans-le-Bourg, have very thin and very fragile plates: they rise to the E.S.E., under an angle of twenty degrees; higher, after having crossed a little bridge, the same schisti are found in an opposite position, or rising to the west. But this position is accidental; it may be said that in general they rise to the E.S.E., following the slope of the mountain."*

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* Sauss. 1234.

Other sites.

This micaceous lime-slate was afterwards observed by our excellent author at the little St. Bernard; and at the Roth-Horn and Mont Cervin, two mountains near the celebrated Rosa, chiefly composed of serpentine.

The subsequent detached observations may also be added from the same treasure of orological knowledge.

Near Morges the mountains are all calcareous, with undulated veins mixed with mica, forming a fine cipolino. The roofs of the houses are covered with thin plates of the same stone.

A bed of primitive lime-slate, between beds of gneiss. It is six feet in thickness; and the layers, of about half an inch, are tinged by some infiltrated green matter.

A lime-slate, analysed, which is incumbent on granite.

Roche Michel, near Mont Cenis, is composed of a mixture of calcareous mica slate and greenish talc, the latter being predominant*.

Aspect 1. Micaceous lime-slate. From Mont Cenis. From M. Cervin, and other parts of the Alps.

The same, from Canada, North America.

A micaceous lime-slate, the limestone being granular and brilliant, as it appears in primitive mountains. Sauss. § 1234.

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* Sauss. § 950, 2225, 872, 1262.

Aspect 2. Common lime-slate. From Gibraltar.

In layers of different colours, from Sweden.

With chert, from Derbyshire.

A fine lime-slate, of a bluish grey, the leaves being very thin and inseparable. Sauss. § 2047.

A lime-slate, with quartz and mica, near Ville Neuve, on the river Doire. Ib. § 955.

Dr. Kidd has given the following interesting account of a quarry of this kind of stone, if he has not mistaken calcareous sandstone for limestone, a mistake which not unfrequently occurs. He calls the substance calcareous slate, or flag-stone; while the latter name is commonly applied to a schistose sandstone, either calcareous or argillaceous. The limestone of Pappenheim, in Germany, rises from the quarry in thick tables, serving at once for pavements, gravestones, or similar purposes, and certainly belongs to this kind, as must the following, if Dr. Kidd's description be exact.

Quarry of Stonesfield.

"There is a very extensive quarry at Stonesfield, near Woodstock, the limestone of which has the property of being easily separated into laminæ by mechanical means, or even by the action of the atmosphere. The manner in which the effect is produced in the latter instance may be understood by a reference to what was said respecting that superficial disintegration which takes place occasionally in calcareous free-stone.

"This variety of limestone is employed very generally for the purpose of covering the roofs of houses; whence it has been called *lapis tegularis.* The property of being thus easily separated into laminæ depends partly upon the proportion of clay contained in it (for this property is in general more remarkable in proportion to the quantity of clay contained), and partly upon the nature of its original deposition; for the stone of some parts of the quarry contains a considerable quantity of minute shells, resembling millet seeds; and it seems worth observation, as connected with the schistose property of the stone, that the deposition of shells is more abundant on the surface than in the substance of the laminæ.

"In some instances a singular arborescent appearance is observable on the contiguous surfaces of adjoining laminæ: the colour of this is for the most part black; and, from some experiments that were made for the purpose of ascertaining its nature, appeared to be principally manganese. The same appearance is observable in some varieties of Florentine marble. Sometimes the colour is only superficial; at others it penetrates far into the substance of the stone. The explanation of the appearance is not obvious; but perhaps some liquid, holding the colouring matter in solution, originally insinuated itself into the clefts by which the laminæ are separated from each other, and deposited this, particle by particle; by something like that continuous attraction, if the term is allowable, which takes place in the freezing of moisture on a pane of glass."[*]

MODE VI. CORAL ROCK.

The texture resembles clustered corals, or madrepores, cemented by limestone[†].

Origin.

This substance has not yet been mentioned in books of mineralogy, though large islands and vast shoals in the South Sea, particularly on the east of Australasia, are wholly composed of it, according to the accounts of navigators. Coral itself is now known to be the gradual structure of minute insects, which thus surpass all the powers of man; for the locust can spread more destruction than an Attila, a Timur, or any other conqueror: and a beneficent monarch can only found a city; while insects almost invisible found islands, and even continents, the scenes of future glory and misery to mankind.

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[*] Vol. i. p. 31. See also Da Costa, p. 144, who adds, that a similar slate is found near Bath. The white flag common in the north of England he ranks among the alkaline calcareous sandstones: it is spangled with mica, sometimes very prettily, especially that with little needles, lying in a diagonal form.

[†] The characters of limestone apply to many of the rocks in this domain, and are therefore not repeated. The characters are also sometimes implicated in the descriptions.

Whether these insects produce the matter of coral, or imbibe it from the waters of the ocean, these islands rise from a surprising depth, and, when they surpass the waves, begin to produce lichens and mosses; which, decaying and rotting, afford a soil for other small vegetables, till by degrees reeds, shrubs, and trees, begin to decorate the new creation. The calcareous soil being fertile, these islands will in the course of centuries invite colonies, whose future mineralogists may perhaps be embarrassed to account for their native rocks; which may at once confer benefits on agriculture and on architecture, for zoophytic marble will not be wanting for the construction of their edifices.

Rocks of a somewhat similar nature abound near Sutherland, on the eastern coast of England; and near Peterhoff, at the further extremity of the Gulf of Finland. This singular limestone seems composed of tubes of madrepore or coral, often with open intervals; and at Sutherland is the common building-stone.

Coral rock, from Australasia.

Madrepore rock, from Sutherland and Peterhoff.

MODE VII. MARLITE.

Description.

The combination of this substance is the same with that of marl, the calcareous earth being mixed with a considerable proportion of argil. Some marbles, which contain from 15 to 30 or more of argil, are properly marlites; and they are apt to decompose in the open air. Such is the green Campan of the Pyrenees, which also contains a considerable proportion of magnesia. Several of the Russian marbles also contain clay, but mixed with a still larger proportion of silex.

The celebrated pictorial marble of Florence, which imitates ruins, and sometimes trees, is properly a marlite.

Marble of Florence.

"This marble presents angular figures of a yellowish brown, on a base of a lighter tint, and which passes, in diminishing, to a whitish grey.

"Seen at a certain distance, slabs of this stone resemble drawings done in bistre. One is amused to observe in it kinds of ruins: there, it is a Gothic castle half destroyed, here it presents ruined walls; in another place old bastions; and what still adds to the delusion is, that in these sorts of natural paintings there exists a kind of aerial perspective, which is very sensibly perceived. The lower part, or what forms the first plane, has a warm and bold tone; the second follows it, and weakens as it increases its distance; the third becomes still fainter, while the upper part, agreeing with the first, presents in the distance a whitish zone, which terminates the horizon, then blends itself more and more as it rises, and at length reaches the top, where it sometimes forms as it were clouds.

" But approach close to it, all vanishes immediately, and those pretended figures, which at a distance seemed so well drawn, are converted into irregular spots, which present nothing to the eye.

" This play of nature is owing to ferruginous infiltrations in the fissures of this marble, which otherwise is of a dull fracture, and very argillaceous; whence it is never used in architecture; they merely make slabs of it, which are framed like little pictures, and which are much esteemed in commerce when of certain dimensions. It sometimes occurs that the same slab is sawed in two, and the parts are set together in the same frame, so as to appear but as one piece; and the drawings on the right and left bear a resemblance, which still farther helps the illusion. There are some, who, to out-do nature, put painted figures at the bottom of these pictures; but this is an exuberance of the wonderful, which finishes by spoiling all."*

Of marlite there are two structures, the massive and the schistose.

STRUCTURE I. MASSIVE.

Aspect 1. Argillaceous marble. Green and red of Campan; but which, from their structure, rather belong, at least in part, to the Anomalous Rocks.

The reddish of Ingermania, &c.

Aspect 2. Pictorial marble. This is said to be massive, though it would rather appear to be schistose. The marble of Cottam probably belongs to this division.

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* Brard, 415. The marble of Oker in the Hartz is white, with regular veins of black clay slate; and may be classed in this division. Jour. des Mines, No. 23, p. 73.

The marlite of Shropshire, called *dye-earth*, more than 100 yards thick, contains small bivalves, and what are called the Dudley fossils, the *entomolithus paradoxus* of Townson. See his Tracts, p. 166, 177.

STRUCTURE II. SCHISTOSE.

Substances in this state generally present a finer grain than when they occur massive. Marl-slate sometimes presents delicate concentric circles, and other delineations, of a light brown upon yellowish grey, its usual colours.

Impressions of fish.

But it is still more remarkable, as being the general repository in which are found the remains and impressions of decayed fish. In this case it is commonly penetrated with bitumen, probably derived from the decomposition of their bodies, as chemists now infer that substance to proceed exclusively from the animal or vegetable kingdoms. Da Costa mentions that of Mount Lebanon, near Tripoli *di Soria* (of Syria), in the province of Castravan*.

The slate, with impressions of fish, from Eisleben, Ilmenau, Mansfeld, &c. were formerly celebrated, and the animals are often delicately delineated, as it were, in cupreous pyrites. At present those of Mount Bolca, in the Veronese territory, have attracted more attention; and the proprietor has filled a whole chamber in the museum of the Garden of Plants with these singular remains. The mud and poisonous vapour, perhaps of a volcanic origin, seem to have surprised and destroyed these animals almost instantaneously, for most appear to struggle, and one is in the act of swallowing another.

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* P. 170. This is the Khesroan of D'Anville, and the Castracan of the Italians, whence the celebrated lumachella.

Saussure has described similar quarries near Aix, towards Lambesc, in the south of France, which also present impressions of leaves of palm-trees. The same great observer has added an account of that of Oeningen, near the lake of Constance, which first presents a thin layer of soft micaceous sandstone, cemented by clay and lime; another of coarse marl and marl-slate; followed by lime-slate, alternating with layers of clay. At the depth of nine or ten feet appears the rock, which contains the impressions; and which is, as usual, a bituminous marlite. The fish are accompanied with several insects, and leaves of trees, some of which belong to warmer climates; but far from being so extraordinary as those of Mount Bolca, which, not to mention more recent discoveries, presented at the time when Saussure wrote, 1795,

27 kinds of fish of the European seas.
39 . . . of the Asiatic.
3 . . . of the African.
18 . . . of South America.

11 kinds of fish of North America.
7 . . . of fresh water of the different parts of the world.
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In all 105.

MODE VIII. ORSTEN.

Name, Swedish. Some of the Swedish appellations ought to be venerated, as that country has produced such able writers in natural history, and particularly in mineralogy; of which science Wallerius, Cronstedt, and Bergman, must be esteemed as the chief founders. The substance now under view has by some of our mineralogists been called *swinestone*, and by the Germans and French less politely *stinkstein*, and *pierre puante*; but as the Swedish name has more brevity, and does not impress a disagreeable idea, it deserves to be substituted.

Description. Orsten is merely a limestone, which, sometimes from a mixture of bitumen, sometimes from yet unknown causes, yields a fetid smell, when worked in the quarry, or in the marble yards, or even when rubbed with any hard substance. In a geological point of view, it has assumed higher consequence, since it was discovered by Ramond to form the summit of Mont Perdu, the highest of the Pyrenees. It is generally of a black colour; but some specimens from Derbyshire are even white, or at least whitish grey. The other tints are chiefly various greys, with brown and Isabella yellow.

Used as fuel.

Mr. Kirwan says that the smell is urinous or alliacious; and that it abounds in the county of Galway, in Ireland, where, as fuel is scarce, it is often employed to heat the rooms, and remains hot for many hours. In the neighbourhood of Vesuvius it is found laminar, alternately white and yellow. It often produces excellent lime.

A grey Flemish marble, now much used at Paris, belongs to this kind, and leaves a very fetid smell in the manufactories. That of the summit of Mont Perdu is a black marble, impregnated with shells and sand. Ammonites and camerines, gryphites, pectenites, with madrepores, and other zoophytic remains, enter into the composition of the singular calcareous chain of the Pyrenees.

Black orsten, from the summit of Mont Perdu.
Grey, with zoophytic remains, from Flanders.
In yellow and white plates, from Vesuvius.
Greyish white, from Derbyshire.

should repose on large masses or divisions; while minute and broken lights only distract the attention and the memory. The gypsous rocks may safely be reduced to two kinds, the coarse and the compact.

Primitive. It was long conceived that gypsum was of the most recent formation, till a rock of this kind, undoubtedly primitive, was discovered by Saussure in the Alps. Dolomieu indeed expresses his wonder, that gypsum has not been more frequently formed from primitive marble, as the sulphuric acid might easily be produced from the decomposition of pyrites. But the remarks of Saussure must not be omitted.

"In regard to gypsum, it is found at St. Gothard, either below Ayrol, as I have said, § 1805, or in the Val-Canaria. It is in mass, of a fine and brilliant grain; it does not effervesce with acids, and consequently is free from all calcareous mixture.

"But what is more rare, is to find gypsum in a schistose form, and mixed with thin layers of mica: this contains some calcareous parts; it slightly effervesces.

"I do not think that this gypsous schistus is a primitive rock, like the calcareous micaceous schistus; I believe it to be of modern origin, and that it originated by deposition in hollows, since the formation of the secondary mountains. The specimens which I possess are of a nature to justify this idea; their texture is not homogenous; the mica does not appear to have been united to the gypsum by a simultaneous crystallisation: it is in plates nearly incoherent, which separate thin layers of an argillaceous sediment. This mica then seems to have been brought down and deposited by the waters, rather than crystallised in them. Nevertheless, as I have not observed it in its native site, I dare not be too decided in this opinion." *

This gypsum was observed by Saussure in passing from Bellinzona to St. Gothard; but we are told by Brochant and Jameson that the primitive gypsum was discovered near Bellinzona; and they add, that it is in layers between beds of mica slate; and Jameson says, along with limestone and hornblende slate. I know not their authority for this assertion; but the objections of Saussure seemed to Patrin so powerful, that he virtually denies the existence of primitive gypsum, by asserting that it is wholly tertiary. The mixture indeed of mica is of little consequence, as it is found in the most recent sandstones; and even that of felspar, as observed by

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* § 1931.

Pallas in Siberia, would not now be regarded as of much importance. The pretended porphyries of Werner should, as already mentioned, be simply referred to their bases; for felspar, like mica, being found in every description of rock, can no longer be understood to alter the denomination.

This gypsum, supposed primitive, has a schistose structure, and approaches to selenite in purity. A pure selenite, dividing at right angles, was discovered by Gillet-Laumont, on the left bank of the Doron, above Moutiers, Mont Blanc; and in the same neighbourhood a fine alabaster, and a red gypsum. This beautiful snow-white alabaster easily splits in cubes, and is of a peculiar texture; it sometimes presents acicular crystals of selenite, with brown spots, which this excellent mineralogist suspects to be ferriferous carbonate of lime*; but he did not express his idea that it was of primitive formation.

Geognostic relations.

But these are minute exceptions; and in general gypsum and alabaster must be classed among the Floetz, the planiform, or horizontal rocks of Werner. Sulphate of lime is commonly a simple rock, like limestone, and sometimes occurs in large masses and beds; but sometimes in layers, alternating with orsten, clay, or sandstone. It sometimes contains crystals of quartz, and in rare instances arragonite and boracite. It also sometimes presents native sulphur; and often appears in the neighbourhood of rock salt. It seldom attains a great height, but forms little precipices, which, when of the purer kind, are distinguished by their white lustre. Hollows, like funnels, are sometimes formed in gypsum, which Saussure, 1238, ascribes to the rain water, which, attacking a soft part, remains, and, gradually increasing, melts the surrounding circle.

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* *Chaux carbonatée jaune, ferrifère*, as marked in the catalogue which he gave me of several rock specimens. The precise site is Salins, near Moutiers, Mont Blanc.

Gypsum is generally of a whitish yellow, or yellowish brown cast; but it also occurs of an ash grey colour, in which case, as Saussure has observed, it can only be distinguished from limestone by the nitrous acid producing no effect.

Montmartre.

One of the most remarkable gypsous hills in Europe is that of Montmartre, near Paris, not only from its producing the plaster best known in commerce, but from its peculiar constructure, and the singular animal remains which have there been discovered. It is thus described by the venerable M. Sage, whose chemical mistakes may be forgiven, in the consideration of the great services he has rendered to mineralogy, particularly by the formation of a noble cabinet, now the public property. The respect due to his excellent heart, and polite manners, is increased by the regret for his misfortunes, during a revolution which at length destroyed itself, by ruining even the natural and eternal aristocracy of talents; so that the members having, as it were, extinguished the eyes, were of course reduced to darkness and perdition.

Sage's description.

"The hill of Montmartre is elevated about forty fathoms above the level of the Seine. The summit is covered with vegetable earth, under which is a bed of sand, mixed with rolled flints. This is seated on layers of marl, of different colours and thickness: this marl precedes and accompanies horizontal beds of gypsum.

"The quarries of Montmartre may be considered as divided into three successive large beds, or masses.

"The first, called *haute-masse* by the workmen, is often more than fifty feet thick; it presents beds placed one on the other, without any sensible interruption, although separated: they are seated on a bed of bluish argil, spotted, about twelve feet thick. This argil is intermixed with marl.

"The second part is called *pierre franche*. This gypsous mass, which is nearly fourteen feet thick, is disposed in contiguous layers, reposing on marl.

"The third part, called *basse-carrière*, presents a gypsous mass of about fourteen feet, divided into six beds, separated from one another by layers of marl. This last part is in the plain, and is incumbent on limestone.

"I shall not undertake to account for the formation of the gypsous hill of Montmartre, as well as those which are contiguous, and form a chain of eight or ten leagues, in a northern direction. Among the naturalists who have written on the quarries of Montmartre, M. Pralon, and the Chevalier de Lamanon, have, among others, given excellent lithological descriptions of this place. The latter affirms, that in this part of the Isle of France there was a lake of gypsous water, which gave birth to these quarries.

"The gypsous hills of Montmartre, Belleville, Pantin, and all those of this part of the Isle of France, are incumbent on quarries of limestone; the gypsous mass only extending to the level of the soil. The shelly and argillaceous rock which is found on the summit of the hill of Montmartre contains white shells, brittle, of the class of chamites, and screw-shells: these shells are analogous to those which are found in the river Marne, and in the rivulet of the Gobelins, as is observed by Lamanon.

"Infiltrations of black martial earth* often form very elegant dendrites, on white limestone, mixed with argil. The dissolution of the limestone, infiltrating between the clefts of the gypsous masses, forms stalagmites composed of undulating layers, often distinct by their shades of brown, yellow, and white. These alabasters vie in beauty with the best of this kind; but hitherto they have only been found in thin pieces, often several feet in length. The limestone which infiltrates into the gypsous masses, is the cause that they almost all effervesce with acids; except the plaster-stone with a coarse grain, the crystals of selenite, and those known by the name of *grignards*, a term bestowed on selenite when it forms regular layers. When these masses are broken with the hammer, they emit a strong odour of decomposed *liver of sulphur*.

"The marl forms beds and masses, more or less considerable, in the plaster-quarry of Montmartre: argil is also found in it in considerable quantity, and in different states: one is tenacious and ductile; the other exfoliates in drying, and sticks closely to the tongue when tasted.

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* Rather manganese.

" Heavy spar* is found in the marl at Montmartre: it is more abundant in the hill of Belleville, where it is met with in misshapen masses, greyish, flattened and rounded, at ten or twelve feet from the surface of the earth.

" The trunk of a tree agatised, which I found at Montmartre in 1778, serves to support my theory on the agatisation of vegetable substances. See page 168, vol. ii. of my *Chemical analysis of the three kingdoms*. This agatised trunk of a tree was thirty feet long, and nine inches in diameter; it was rather compressed, lying horizontally from north to south, and was at least 100 feet from the summit of the hill, between the two lowest beds of gypsum, of which the interior part was crystallised. The interstices of this agatised wood are ornamented with little regular rock crystals, of various colours. A part of this wood is brown and compact: this colour is owing to iron and oil, principles of the woody substance. I have inquired, since then, if any agatised wood had been found at Montmartre, and I was assured that it had not.

" The shelly sandstone which is found at Montmartre, seems of the same date with the agatised wood: this sandstone contains white calcareous muscles and clams. For the most part, it only presents the impression of these shells. In regard to the sand and flint, which are found in the upper layers of the hill of Montmartre, they have no peculiar character, and do not appear to differ from those found on the sides of rivers; but in the masses of gypsum is found whitish silex, striped, and formed in this quarry, like the masses of shelly sandstone.

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* Strontian.

"In the hill of Belleville, two feet from the soil, are found black flints, in beds formed in irregular heaps; they lie in a kind of marl, which reposes on a bed of gypsum of ten or twelve feet, the layers, which are of different thickness, being intermixed with marl: this layer of gypsum lies on a considerable bed of green argil, under which the gypsum is again found *.

Bones.

"The bones which are discovered in the gypsum, have undergone no other alteration than that effected by time: the greater part have a yellowish tinge. M. de Joubert has observed, that these bones are always surrounded with a kind of marl, which he regards as being produced by the decomposition of the soft parts of animals. In the cabinet of that naturalist

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* This green clay corresponds with that of the river Marne, which is green. It contains iron. See Vauquelin's analysis.

there are icthyolites; the impression of the fish being compressed, as in schistus: nor are the fish solid, as in limestone.

"M. d'Arcet possesses an ornitholite, or petrified bird, which he found, in 1781, twenty fathoms below the summit of Montmartre *.

"It has not yet been decided to what species of animals the bones found in gypsum belong. If these bones are neither agatised, nor penetrated with gypsum, it is because the absorbent earth, which forms their base, is found to be combined with phosphoric acid, and a fat substance †; consequently the selenitic water has not been able to decompose these bones.

"The brown hepaltic iron ore, solid, in an irregular mass, which is found dispersed in some places in the hill of Montmartre, seems to be the product of decomposed pyrites.

"The calcareous and gypsous *ludi*, in a spheroidal mass, flattened, called by the workmen *miches de quatorze sous*, are found to the east of Montmartre, near Clignancourt, in a bed of marl, from twelve to fifteen feet below the summit of the hill. Among the *ludi* of this kind, which are in the cabinet of the royal School of Mines, there is a spheroidal mass, flat, of two feet diameter, and seven inches thick; all the exterior crust is calcareous, granular, greyish, and a little argillaceous: it is an inch and a half thick. The interior of this *ludus* is filled with gypsous prisms, greyish, pentagonal and hexagonal, with interstices between them. These prisms are two or three inches in height, and one in diameter; their surface is strewed with small brilliant crystals.

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* It seems to be a water-rail.

† The *acidum pingue* is a fav ourite teet of M. Sage.

" The farinaceous gypsum, or white gypsous earth, is sometimes found in the form of *guhr*, but the crystalline gypsum forms considerable beds: they are often intermixed with *grignards*, or crystals of selenite, forming continued layers. Lenticular selenite is found in the marl: these crystals, grouped in different ways, have been precipitated from the aqueous fluid which held them in solution; the marl, which has afterwards settled, has encrusted, surrounded, and protected them. They are found in great quantities at the foot of Montmartre, towards Monceaux.

" Basaltic selenite, or in hexahedral prisms, with trihedral summits, alternate, with a curved surface, is found in the marl, near the summit of the hill of Belleville.

" Prismatic decahedral selenite, produced by the elongated octahedron, truncated near its basis, is very scarce at Montmartre; but is common in the hill of St. Germain-en-Laye, where it is found in grouped crystals, spread in a red veined clay, which precedes the beds of limestone, found towards the summit of the hill.

"At Montmartre I also found striped selenite, in small layers of two or three lines in thickness." *

One of the most singular discoveries made at Montmartre was a horse-shoe, partly corroded by age; but more than the half remains with the holes very distinct. It is said to have been found at a great depth in the solid mass, and had most probably dropped into a reft, afterwards filled by stalactitic matter, a common appearance in gypsous regions.

Fossile bones did not attract so much curiosity when they were carelessly examined, and supposed to belong to known animals. But the singular discovery in South America of the entire skeleton of an animal larger than the elephant, and of quite a different genus, and now totally extinct †, led to more minute investigations and comparisons, till it was at length

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* Sage, Supplement à la Description Methodique du Cabinet de l'Ecole Royale des Mines. Paris 1787, 8vo. p. 124.

† See the print, Faujas, *Essai de geologie*, from the large plates engraved by order of the King of Spain.

discovered by microscopic eyes, that even the insects found in amber are not of the European kinds, but belong to distant regions. In the comparative anatomy of fossile bones, the celebrated Cuvier greatly distinguished himself, and by patience and research has nearly completed three skeletons of those found at Montmartre. For they belong to three kinds of animals, of the same genus, but of very different stature; one only attaining the size of a hare, the second of a hog, while the third reaches the size of the horse. Those animals approached the nature of the rhinoceros, the hog, and the American tapir, but were more nearly allied to the latter. Being herbivorous, as appears from the teeth, easily distinguishable from those of carnivorous animals, their bones seem to have been rolled down by the river to the spot where they are now found.

Shells. It might be imagined, that there is a kind of artful malice, if the expression may be pardoned, in the bosom of the goddess Nature, which allows human theory to sport for some time, and then brings out her stores for its destruction. It was long conceived, that fossile shells were confined to limestone, and fossile bones to gypsum, till very lately most of the sea-shells, found in the highest state of preservation in a bed of sand at Grignon, about four leagues beyond Versailles, have also been discovered in the gypsum of Montmartre. Most of the shells found at Grignon, some of which retain their most delicate spines, and even their colours, are known now to belong to the South Sea, a portion of the Grand Ocean falsely called the Pacific; and but few to the Atlantic, or even the Mediterranean.

The various beautiful kinds of selenite, or crystallised gypsum, found at Montmartre, belong to lithology. The curious kind called vegetable selenite, from its resemblance to vegetation, seems confined to Derbyshire.

Aspect 1. Common gypsum, from Montmartre.

The same, with selenite, often elegantly interspersed with farinaceous gypsum.

The same, with blue variegated clay.

The same, in small layers of marl, &c, forming, as it were, a Montmartre in miniature.

The same, with imbedded ossilites, or bones of quadrupeds and birds.

The same, with various sea-shells; a recent and curious discovery. Brongniart says that some of the marl beds contain cardites, venerites or dionites, tellenites, cerites or screws (turbinites), and even bones of fish, and trunks of the palm-tree. Small pieces of iron-stone also appear, particularly on that side where the gypsum once bore a prismatic form, now destroyed by the progress of the quarriers, and which probably arose from the influence of that metal.

Aspect 2. Grey gypsum, from Mount Cenis. The same, from Germany.

MODE X. ALABASTER.

Characters. Texture, compact, generally saline, but fine-grained; sometimes fibrous, even in large masses.

Hardness, gypsic. Fracture, even, sometimes scaly. Fragments, amorphous, rather blunt.

Weight, carbonose, sometimes granitose.

Lustre, glimmering. Sometimes translucent, even in pretty thick pieces; often only on the edges.

The colour is generally of the purest white, sometimes slightly veined with grey: but when stalactitic, it may be veined with yellow and brown, by ferruginous infiltrations. In small veins it may assume a rose colour, as at the Old Passage, near Bristol, where it is however too soft to be polished. It may also, like that near Nottingham, appear blue when held between the eye and the light.

It is now proper to pass to the consideration of that fine compact gypsum called alabaster. This substance, like alabastrite, is regarded as being a *sinter*, or deposition; but from gypsous rocks. Hence it is commonly found in small layers, and being rather soft, is used for little statues and ornaments. Yet Gmelin, who has ranked it under gypsum, assures us that it forms entire mountains, or at least very large strata, in Thuringia and Siberia*; but he probably confounds it with alabastrite, the ancient or calcareous alabaster. If, as Mr. Kirwan asserts, even mountains of gypsum are found†, alabaster may fill prodigious caverns. While Werner and his disciples are perhaps too minute in lithology and metallogy, they are in petralogy far too theoretic and general: but if gypsum be found, as they assert, in rocks distinguishable by their white colour, they must belong to alabaster. In fact, what has been styled primitive gypsum, particularly the cubic of Salins, Mont Blanc, is the purest alabaster; and naturalists ought to attend to common distinctions, and the purposes

Sites.

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* Linn. 118.

† Geological Essays, 238.

of art and utility, else the sapphire and the ruby might be confounded with corindon. It may seem particularly doubtful whether the kind called *anydrous* by the French mineralogists, because it contains no water of crystallisation, can properly be regarded as a *sinter*, or deposition from other beds; particularly that of Vulpino, which contains silex, and has been quarried for many ages. If gypsous alabaster form beds, which alternate with orsten and limestone, it cannot be regarded as the mere production of other rocks.

Mr. Jameson, who deserves to be mentioned with respect, upon account of his assiduous services to mineralogy, in treating compact gypsum, observes, that "it occurs almost always ash grey, passing into smoke grey, also yellowish grey;" and closes thus, "It is employed in architecture and sculpture, under the name alabaster." Nothing surely can be more contradictory to the common sense of mankind, except Mr. Werner's new and elegant appellation of White-stone, thus introduced to his audience by a German Professor, "White-stone is always grey." The ingenious and intelligent Brard, though a mere youth, gives a more rational account.

Brard's account.

"Gypsous alabaster does not effervesce in nitrous acid; it loses its transparency, its lustre, and solidity, when exposed to fire; that is to say, that it changes into plaster.

"It is so soft as to be marked with the nail, and yet it takes a pretty fine polish; but it is true that the least friction will destroy it.

"It is never decked with lively colours; milk-white is its colour by excellence.

"Its transparency is sensible, even through thick plates.

"In short, its fracture or internal aspect varies much; sometimes it presents a crystalline and bright tissue, sometimes only a laminar contexture, or at other times only a dull and compact surface.

"As gypsous alabaster is much oftener white than calcareous alabaster, it is to that kind that the old proverb should be applied of *white as alabaster*."*

Monuments.

He informs us that the statues of the superb mausoleum of the Constable Lesdiguieres, in the cathedral of Gap, are of gypsous alabaster, from Boscadon, near Embrun, in the department of the Upper Alps. It is probable that those in the English cathedrals, generally executed by foreign artists, are of Italian alabaster. The alabaster of the department of Mont Blanc, of the most beautiful white, sometimes veined with grey, and receiving an exquisite polish, is much employed at Grenoble, the Gratianopolis of antiquity, and the chosen seat of Venus and Apollo.

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* P. 468.

Anydrous. The alabaster called *anydrous* is of several colours, white, rose, grey, and even blue, which is called celestine, a name now strictly belonging to a kind of strontian. The white anydrous kind is also found at Vizil, near Grenoble; and was used by the Romans, as appears from the beautiful mile-stone, or rather column, at Thin, on the banks of the Rhone, which is six feet high, and erected in the time of Aurelian*.

Anydrous alabaster, mixed with a considerable quantity of silex, forms the *bardiglio* of the Italians, found near Vulpino, fifteen leagues from Milan, and employed in making columns, tables, and vases. It properly belongs to the Diamictonic Domain, where it is more particularly described.

White alabaster, from Derbyshire.

With a blue transparency, from Nottingham.

White alabaster, from the lower Pyrenees.

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* Ib. 479.

Yellowish white alabaster, from Lagny, about twenty miles from Paris, where it is used for columns and vases. It is translucent, and full of little cracks, which however do not affect its solidity.

Bright grey alabaster, with green and yellowish spots, from the river Niso, in Sicily; which affords many curious marbles, and other substances.

Gypsous alabaster, waved with red and deep yellow; from Taormina, in Sicily; another remarkable spot for a variety of marbles and serpentines, some of which were known to the ancients.

Translucent alabaster, of a bright yellow waved with white; from the isle of Gozzo, near Malta.

Travellers seldom observe whether a substance be found in such abundance, as to be useful to the arts. Hence even celebrated cabinets are, in the present confusion of the science, filled with specimens from little fragments, or boulders, and vein-stones, which merely please the eye, and lead to no solid purpose of utility or science. A final and perpetual division into lithology and petralogy, would obviate this among many other inconveniences.

Anydrous alabaster, from Grenoble.

MODE XI. CHALK.

Characters. Texture earthy, rather fine, on a large scale generally stratified, with interposed layers of detached flints at regular intervals. The flint is sometimes schistose and continuous, as in the neighbourhood of Margate, and the North Foreland.

Hardness, of course, cretic. Fracture, even, earthy. Fragments amorphous, blunt.

Weight, pumicose.

Lustre, dull. Opake.

The colour is a dull white, proverbially known, but, wanting the brightness of alabaster, has never been used to celebrate the charms of beauty. From the decomposition of the balls of iron pyrites, which it often contains, it may in parts assume a yellowish or greyish tint.

Sites. Chalk not only forms rocky cliffs, of a most regular, bright, and imposing aspect; but may be said to constitute whole regions. A large portion of the south of England, and the north of France, consists of chalk; which, in Hampshire and Kent, is often covered with the hop; and in Champagne affords a light vivacity to the vine. It also appears in the flat islands of Denmark; while, in other countries, it must rather be regarded as a rare production. This extent of chalk in a N. E. direction, and its absence in the other parts of the world, is a most grand and singular geological fact, which does not seem to have invited deserved attention.

Mr. Jameson's account is so concise and exact, that its insertion will please the reader.

Jameson's account.

" 1. This appears to be one of the newest of the floetz formations, and is nearly the last link of the great limestone series.

" 2. It is very simple; for it contains, besides chalk, only a small portion of flint. The flint occurs in tuberous shaped masses, or in the form of petrifactions imbedded in the chalk; and sometimes it forms thin beds, which are more or less continuous, and alternate with thicker beds of chalk. It contains but few petrifactions, and these are principally echinites, ostracites, and belemnites.

" 3. It is more or less distinctly stratified. Like all new formations, it contains but few metalliferous fossils. All that have been hitherto found, are iron pyrites in small balls, and small portions of iron ochre.

" 4. Very few observations have been hitherto made, with the view of ascertaining its relative antiquity. Its occurrence on the sea-coast, and its earthy aspect, point out the lateness of its formation.

"5. It occurs only in low situations, and most frequently on sea-coasts, where it forms considerable cliffs; but when it occurs in inland situations, it rises into hills of considerable height.

"6. In England, it extends through Wiltshire, Hampshire, Surry, Middlesex, Essex, and Kent; and appears on the opposite coast of France, and stretches through the Netherlands. In the Baltic, it occurs in the islands of Zealand, Moen, Rugen, Wollin, and Saltholm; and it extends from Saltholm to the Swedish province Schönen. According to Dr. Steffens, the chalk at Stevens-klint in Zealand, and that of Moèn, rests upon an aggregate of nautilites, serpulites, chamites, and corallites."

Shells. To the petrifactions may be added vast decomposed ammonites, as at Margate, pectenites, large pinnites, as at Meudon, near Paris, the glossolites or glossopetræ, called petrified palates, often of a bright brown and great beauty*; with what are called Judaic stones, seemingly spines of a large sea-urchin, dionites, &c. It has been remarked that the petrifactions in chalk seem more ancient than those in many limestones; and Brongniart has observed that they are chiefly pelasgian. The shells are often changed into flint, particularly the echinites. Sometimes unaccountably the shell retains its original appearance, and even lustre when broken; while the interior is a mass of solid flint, which has also been found to pass through the shell without affecting its texture, which could not have happened if the flint had been in a state of fusion from heat.

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* See Woodward and P. Tr. No. 232.

Patrin informs us, from Buffon, that a chalk region is also found in Poland; but he adds particularly in the territory of Sadki, where it is only found above an iron mine, with beds of other substances. This may perhaps be a soft white limestone, like that sometimes used at Lyons, and which has also been employed in building the famous bridge of St. Esprit over the Rhone. Some regard this last as a highly indurated chalk, which may be cut with a common saw, and becomes, like most other stones, more solid by exposure to the air, losing what the quarriers call the *rock water*.

Indurated.

There is, on the other hand, a kind of chalk, which may be regarded as crude and imperfect, often consisting merely of comminuted shells;

and such are the falunes of Touraine, and other parts of France.

Uses. Its use, as a manure, seems to have been long known; and the numerous chalk-pits in England, sometimes of vast extent, have been dug for this and other purposes. When cleared by water from foreign particles, it is allowed again to condense, and sold under the name of whitening. Spanish white is merely refined in this manner; and the name is arbitrary, as it is manufactured in the north of France. Spanish white not having the poisonous qualities of white-lead, there is room to regret that it is not brought into more general use. Such are, it is believed, the chief consumptions of chalk; the use of which is rather condemned at the alehouse; but it is also sold at the shops for many domestic purposes. In Woodward's time, the British seamen generally carried chalk eggs from Kent, being echinites, supposed to contain the purest kind. They were used to correct sickness, diarrhœa, and other disorders of the stomach, arising from salted or gross food; and the absorbent powers would be approved by the modern physician, especially if chalk contain 11 of magnesia, as asserted by Bouillon Lagrange; but other chemists have only found about 60 of lime, and 40

Chalk eggs.

of carbonic acid[*]. The chalk-stones which appear at the joints of gouty persons, and greatly resemble that substance, are now said only to consist of uric acid and soda.

The structures and aspects of chalk, are rather various in minute parts, than in general masses; so that an excess of precision in this respect might, as sometimes happens, only introduce erroneous ideas.

Chalk, with various shells; from many parts of England, France, and Denmark.

The same, with the shells in flint.

The same, with balls of pyrites divergingly radiated.

MODE XII. TUFA.

Description.

The name of calcareous tufa, is most justly applied to a light and porous rock, gradually formed and daily increasing by the depositions of springs and streams much impregnated with stony matter. It is, of course, the newest of all the mineral productions; and often contains

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[*] Da Costa, p. 77, says that chalk, called *creta*, from Crete, where it is found, as it is, among other places, in the archbishopric of Cologne, is used for the heartburn and diarrhœa. It is also employed in manures, to cleanse metals, and in baking sugars.

Very modern.

moss, grass, and other vegetables. The formation in many instances is so rapid, that it is applied to the purposes of art. Nests of birds, and other small objects, are subjected to the stream; and, when covered by the deposition, are said to be petrified; an erroneous idea, for they are merely clothed with tufa. Such is the tufa common on the banks of the Tees, and other rivers in the north of England. By its lightness it is well calculated for vaults and roofs in buildings, where the use of wood would be dangerous; and, by its open intervals, admits the mortar, so as to form as it were one coherent mass; and it was used by the ancients in many constructions. The Pharos, at Dover, is chiefly built of tufa, from the north of England*.

Conchitic.

But as the Italians first used the word *tufo*, and seem more generally to have applied it to volcanic accretions, there is no impropriety in extending it, as is often done, to many loose and porous stones, evidently of recent formation. Thus the shelly tufa of Gmelin, consisting of broken fragments of shells, with sand and gravel, loosely joined by a calcareous cement, might perhaps be more properly classed here than among the glutenites. Of this stone the celebrated temple of Jupiter Olympius at Agrigentum, or Girgenti, in the south of Sicily, was constructed, as appears from the ruins. The coarse limestone of Saillancourt, used in building the beautiful bridge at Neuilly near Paris, also approaches to this kind.

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* This tufa seeming to join substances together, was exhibited by the surgeons in the fracture of bones, and called *osteocolla*.

The *Travertino*, with which the church of St. Peter, at Rome, is constructed, is also a tufa, daily formed in the waters of the Anio, now called the Tiverone.

Of aqueducts.

A fine calcareous tufa is also formed in ancient aqueducts, in like manner as we see it every day in our tea-kettles. The ingenious Brard says, "Being in Languedoc, towards the middle of June, 1807, I visited the great Roman aqueduct, known by the name of Pont du Gard: I ascended into the gallery which terminates this bold monument, and in which, anciently, the water ran which was conducted from Uzès to Nismes: I observed that the sides and bottom of this canal are encrusted with coarse tufa, 18 inches thick. In like manner also, and what has happened under the eyes of the Parisians, when in new modelling the garden of the senate, there was found, in digging the soil, canals; which are said to be as ancient as the time of Queen Blanche, and which brought the water from Arcueil to Paris; and these canals were entirely filled with the same sediment which that water deposes, even now, on the surface of all bodies on which it remains a certain time."[*]

Some establish a distinction between tufa and sinter; that the former is deposited in the open day, while the latter is formed under ground. But this seems arbitrary; and depositions of the purest alabaster, or alabastrite, may be equally formed in the open air, as at the Baths of St. Philip, in Tuscany, where they appear equal to the most beautiful marbles, being received in moulds with the heads of Roman Emperors, and other objects. This ingenious manufacture was established by Mons. Vegni. But such objects belong to lithology; and the name of tufa will ever imply a coarse stone used in architecture.

St. Felippe.

Travertino.

Of this kind, by far the most celebrated is the *travertino*, already mentioned; as it has been employed, both in ancient and modern times, in the construction of the most magnificent edifices of the most magnificent city in the world[†]. Hence a more particular account will be found interesting, and shall be given in the words of a skilful observer.

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[*] Brard, 466.

[†] For example, the Coliseo or Flavian amphitheatre. Petrini, i. 138, says the Travertino is of a sweet yellowish white, and hardens by time.

"The Anio or Tiverone, which descends from the Apennines of Vicovaro and Subiaco, to the east of Rome, before reaching the plain where it unites with the Tiber, crosses Tivoli; a place equally known to the learned and the artist, by its ancient monuments and its beautiful views, which have employed the pencils of the greatest masters. All the land through which the Anio passes in Tivoli, whether near the great cascade or the smaller ones, is filled with masses of a calcareous stone, produced by the deposition of its waters. Sometimes a piece of rush or reed, or other vegetable matter, is the first point to which the calcareous earth begins to attach itself. It generally deposes in concentric layers, and has the hardness and fibrous tissue of alabaster. These layers are nevertheless separated by a bed of calcareous earth, friable, yellowish, and very fine. At the foot of the mountain of Tivoli, where the Anio enters the plain, which extends to Rome, are the quarries of travertine. This calcareous rock is disposed in horizontal beds: its colour is yellowish white, its grain earthy, fracture uneven, and its hardness far surpasses that of those calcareous masses produced by the Anio, in the neighbourhood of Tivoli. Cavities, where the calcareous substance has assumed a sparry grain, and stalactitic forms, are common in travertine. Sometimes these cavities have been since filled by a calcareous stalactite, whiter, of a finer grain and harder. This is the origin of those white spots; the regularity of which, has caused them to be mistaken for marine bodies enveloped in its paste. Travertine contains no remains of marine substances; but sometimes it affords fragments of vegetables.

"It is not doubted but travertine owes its origin to the depositions of the Anio; depositions which, in the plain, may have formed a more solid and compact rock; because its current was less rapid, and perhaps its waters more stagnant in several places. Not far from the quarry of travertine is the Solfatara, so called on account of the great heat of its waters, which abound in sulphuric hydrogen gas, and form a considerable sediment of calcareous matter. A Cardinal d'Este caused the canal to be dug, which conveys the waters of the lake to the Anio. The calcareous depositions are there so abundant, that, if every three years it was not cleaned out, it would be closed up, notwithstanding its breadth and depth. The water which runs in the canal, on meeting with bits of rush or other bodies, covers them with a white calcareous crust, two or three lines in thickness. These incrustations are known by the name of Comfits of Tivoli*. Before this passage was opened, the overflowings, to which the lake is subject, were often so considerable that the water spread over the neighbouring grounds, and formed on their surface a stony crust. The water of the lake so charged with calcareous earth, uniting with those of the Anio, in the floods which their union must produce, have themselves contributed to the formation of travertine. I do not think that the Anio alone would have been capable of forming the quantity which is found of that rock.

"Independent of the immense quarries worked by the ancients, there are besides others of such vast extent, that they may supply the demands for many ages.

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* "Dr. Vegni had established there a manufacture of bas-reliefs, analogous to that which he possesses in Tuscany, near the Baths of St. Philip. The ingenious method by which he forces the water to form the bas-reliefs in a short time, which by the exactness of the design and the hardness of the stone, are not inferior to the originals, is sufficiently known by the relations of most modern travellers in Italy.

"I shall only add, that the colour, grain, and hardness of the stone formed by the waters of the Solfatara of Tivoli, as well as the neighbourhood of Rome, which furnishes so many beautiful models, and skilful artists, give this manufacture a decided advantage over that of Tuscany."

"The lake of Solfatara seems to have greatly assisted in the formation of this rock. Its water, charged with much gaz, explains by that quality the great number of hollows which travertine presents. It proves that when the rock hardened, a gaz has at the same time escaped in several places, which has prevented the approximation of its parts which were still soft. As often as the interior of a mass of rocks presents cavities, without any indication of foreign substances, which might have opposed the union of its parts, I conceive their origin may be attributed to the escape of gaz, at the moment when the substance was passing from a state of softness to solidity, by cooling or drying.

"From what I have just shown, it follows that travertine, or rock of Tibur or of Tivoli*, is a carbonate of lime, formed by the depositions of the Anio and the Solfatara of Tivoli. The Roman artists give the name of travertine only to the stone taken from the quarry, situated at the foot of the mountain of Tivoli. The lithologists, less slaves to locality, bestow it on all calcareous rocks which possess the grain, tissue, and formation analogous to that of the travertine of Tivoli. If the ancient and modern

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* *Tiburtinum* of the ancients.

Romans have employed this stone in the most noble structures, they have but followed the examples of other people before them. The temples of Pestum, the most ancient monuments that are known after the pyramids of Egypt, were built with a travertine, formed by the deposition of waters which still exist in that district. This stone, when long exposed to the air, acquires a considerable degree of hardness; its colour assumes a reddish tinge, pleasing to the eye, and which in no small degree contributes to bestow on monuments of antiquity that majestic character which is so striking. Buch justly observes, 'that the temples of ancient, the churches and palaces of modern, Rome, would infinitely have lost of their grandeur and majesty, if the bold genius which erected them had not met with such a material as travertine. They would have lost much of their solidity, if the formation of tufa had not given rise to the discovery of puzzolana.' The chance which collects in its vicinity the materials most fit for architecture, travertine, and puzzolana, was not a little happy for Rome. The mortar or cement, which results from a mixture in just proportion of that ferruginous volcanic earth with lime, so much surpasses in hardness all other known cements; that the exportation of puzzolana, by the Tiber and the Port of Ostia, is become a little branch of trade."*

From the preceding observations, it might be understood that there are at least three different structures of the calcareous tufa: the porous, or that of the travertine; the shelly, like that of the ruins of the temple of Jupiter; and the tubular, like that of Germany, and the north of England.

STRUCTURE I. POROUS.

Travertine, from the ruins of Rome.
The same, from the quarries near Tivoli.

STRUCTURE II. CONCHITIC.

From the ruins of Agrigentum or Girgenti. It is found in many other places, but has excited little attention, being probably regarded as a coarse limestone; while its lax composition refers it to this mode, though Wallerius would perhaps have called it a tufaceous limestone.

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[*] Breislak, ii. 261. At Bionnay there are houses built of a calcareous tufa, containing fragments of lime-spar, limestone, and slate; the base being of a lively brick red colour, and strongly effervescent with acids. Sauss. § 752.

STRUCTURE III. TUBULAR.

From the tower, or ancient pharos, at Dover Castle.

The same, from the banks of the Tees, and other rivers in the north of England.

The same, encrustrating various objects, as birds' nests, plants, leaves, &c.

MODE XIII. CALCAREOUS INTRITE.

This mode is rare, and of little consequence, especially as the stones are not remarkable for beauty, and seldom used in the arts.

Porphyritic.

The most singular, is what Werner would call a limestone porphyry; being a compact limestone of a reddish white colour, sprinkled with minute crystals of white felspar. It was discovered by Gillet Laumont, in the mountain called Bonhomme, in the Alps.

Marble of Nonette.

Another calcareous intrite is a fine grained limestone, with angular spots of calcareous spar, something resembling a porphyry. It is of a yellowish white colour; and bears the name of marble of Nonette, from a place situate at the confluence of the rivers Alagnon and Allier, in the department of Puy-de-Dome. There is also a conchitic marble found near the same place; but the former being more easily worked, is preferred for chimney-pieces and other objects, according to the information given me by M. Lucas, a most obliging and intelligent youth, who has published some useful works on mineralogy. The father has the care of the collection of the *Jardin des plantes*; and by his respectable character, and gentle manners, prevented many outrages that were offered to that sacred deposit, during the times of anarchy.

MODE XIV. CALCAREOUS GLUTENITE.

This mode presents many important objects, as the celebrated bricias and kollanites in marble, with the calcareous sandstones, used for various purposes of construction. It falls, as usual, under two divisions, the large grained and the small.

STRUCTURE I. LARGE GRAINED.

Bricias of limestone are common at the bottom of many calcareous hills, but attract little attention; except in colour and grain, they belong to that noble mode called marble. A singular kind, described by Saussure, may suffice. He observed it at the Col de la Seigne, near the mountain of Bonhomme.

Singular bricia.

"On this road we find a quantity of fragments of a very singular calcareous bricia; and continuing to ascend, we leave on the right, above the path, the rocks from which these fragments are detached. The same bricias are again found in the same situation, on the opposite slope of the Col de la Seigne, and in the White Alley: but I shall describe them here, that I may not return to them. The paste of these bricias is sometimes white, sometimes grey; and the fragments which it contains, are some white, some grey, others brownish red, and almost always of a different colour from the paste which unites them. They are all of a calcareous nature, at least such were all those that I could see; and it is remarkable that they have all a lenticular form very much flattened, and that they are all placed in the direction of the plates of the rock: one would say, on seeing them, that they had all been compressed and bruised in the same direction. This same stone is mixed with mica, especially in the interstices of the layers, and between the fragments and the paste which unites them; but no mica is observed in the fragments themselves, Infiltrations of quartz are also found in these bricias. This rock is cut by frequent fissures, perpendicular to the planes of the beds. It is palpably seen, that these clefts have been formed by the unequal subsidence of the beds, and not by a spontaneous retreat: for the pieces, or foreign fragments, are all divided, and distinctly cut by these fissures; while in the natural divisions of the beds, these same fragments are entire, and projecting from the surface. The nodules of quartz, and the several crystals which schisti contain, present the same phenomenon; and the same consequence may be drawn from it; they are *divided* in the clefts, and whole in the separations of the layers.

"Although these flattened fragments, as I have said, afford, at first sight, the idea of compression, yet I cannot admit it; no other vestige of this compression being observable: I should rather imagine that these fragments have belonged to very thin layers, which have been rounded under the waters, by rolling and friction; that afterwards, when they have been successively carried down and lodged by the waters, they have taken the horizontal position that their weight imposed on them; and that afterwards the elements of the calcareous stone which forms the base of the bricia, and which was deposited at the same time, or alternately with them, have enclosed and kept them in that position."*

The *nagelfluh* of the Swiss is a bricia, with a calcareous cement; the fragments seem to be commonly siliceous; but Mr. Jameson says that a kind, wholly calcareous, is found in Bavaria; it is incapable of polish.

It is singular that no bricia can be clearly and positively assigned to the times of ancient art. Ferber informs us, that the Italians apply the word bricia to any marble, which has spots that are clear and distinct; while it ought to be confined to real bricias, consisting of fragments joined by a calcareous cement.

African bricia.

The bricia which seems to have the best claim to antiquity, is that called the African, which, on a black ground, presents large fragments of a whitish grey, of a deep red, or of a dull purple. Of this marble there is a large column in the Napoleon museum; but the name of African seems to have been bestowed merely on account of its black ground; for it is not mentioned by any ancient author, and, if known to antiquity, was probably Grecian; perhaps the Chian, with spots of many colours on a black ground. As the walls of their city were built with this marble, the question might perhaps still be settled by a learned traveller. When they showed them in a boasting manner to Cicero, his dry sarcasm, on their great pride and small domain, was, "I should have admired them more, if they had been built of travertine." After all, this marble may perhaps be Italian; for Ferber informs us that the same kind is still found at Seravezza, on the opposite side of the mountain to Carrara, which is also called *Africano*, and employed instead of the antique*. The names, imposed by the ignorant and interested dealers and artists, deserve no credit; and an intelligent traveller must study the marbles in the undoubted remains of antiquity, beginning with those which continued in general estimation and use for many centuries, as the Laconian, the Phrygian, the Numidian, and the imperial or Egyptian.

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* § 841.

Antique. No other bricia appears in Ferber's catalogue of the ancient marbles of Rome; but some others are styled antique, probably only on account of their beauty. Such are the rose bricia, which, on a base of bright red, is enriched with little spots, rose and black, with larger ones of a beautiful white; that called *arlequino*, which on a pale yellow, presents many fragments of various colours, resembling the beautiful bricia of Aix, but with more splendour; the chocolate brown, with little angular fragments of white; and the white with red fragments. What is called the grand antique, is composed of large fragments of black in a white cement*. The French apply the name, violet, to a bricia, which, on a ground of pale brown, presents fragments of lilac and of white. One of the violet bricias, described by Brard, is of a yellowish green; and presents white, green, violet, red, and orange spots: but our author does not seem carefully to distinguish between Italian bricias, which are often merely spotted, and the real bricias, which are composed of fragments. Violet.

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* Da Costa, p. 211, positively informs us that the black marble with red and white spots, is Italian, though called African.

Among the bricias of modern Italy, may be mentioned what the French also call violet-bricia, being merely of a reddish brown, with white veins; that of Brentonico with large yellow, grey, and rose spots; that of Bergamo, of black and grey in a greenish cement; and that of Alcamo, in Sicily, of a bright grey with rose spots. The territories of Verona and Trent yield a beautiful bricia of pale red, crimson, and bluish fragments in a red cement. Spain boasts the bricia of Riela, in Ar- Modern. Italy. Spain.

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* Brard, 340.

ragon, of a reddish yellow with fragments of black; and those of Valencia, of a pale yellow. That of Old Castile is much employed at Paris, being of a bright red, dotted with yellow and black, and enclosing fragments of a pale yellow, brick red, deep brown, and blackish grey*. They are rather round, so that it might be called a pudding-stone, if this division were natural; for in the original and beautiful pudding-stone of England, whose name has passed into all languages, the small pebbles are often angular, which, with many other instances, shows the division is unnecessary.

No bricia worth mention, seems hitherto to have been discovered in the British dominions.

France.

Brèche d'Aleppe.

France presents a beautiful marble of this description, very common at Paris. The ground is, in some pieces, of a pale brownish red, in others of a straw colour; and is itself chiefly composed of very small fragments of the same colours with the larger, which are of all shapes, and from half an inch to two or three inches in size. These spots are generally of a light brown, or straw colour, and are interspersed with other fragments of a slate blue and pale red, with others of a light grey and dull white: a striking singularity is, that the large brown spots have sometimes red edges, and an oval or triangular spot of light grey will have a red spot of the same shape in the centre; so that the very fragments would seem to be of original crystallisation, which has been modified, or rather disturbed, by some violent cause, at a particular period of its progress. This singular marble might, with the English kollanite, form a cabinet of study for the geologist; for the appearance of both is utterly irreconcileable with received opinions. As sand is now allowed to be often a product of original crystallisation, so pebbles, which are only a larger sand, must in the kollanite, and may in this calcareous rock, be of original formation, and afterwards agglutinated by a resumed progress of the process.

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* The celebrated *brocatello,* or cloth of gold of Catalonia, is by some regarded as a bricia.

This singular bricia is at Paris called *brèche d'Aleppe*, as if it came from Aleppo in Syria; but M. Brongniart informs us that this is a corruption, and that it should be called *d'Alet*, from a place about a league from Aix; yet he describes it as red, black, and grey, which must be quite a different sort. Brard, who has treated the French marbles with great care, says, that the bricia sometimes called of Aleppo, and sometimes of Alet, by the marble-cutters of Paris, is the antique violet bricia, which has been already mentioned;

but none of his descriptions in the least correspond with that under view[*]; and it is with regret that on this and many other occasions, the praise of accuracy, though it ought to form the chief ambition of such a work, must be withheld. It is also surprising that he did not learn, from Brongniart, that the bricia of Aix, which he compares with the *Arlequino*, must be the same with that of Alet in the vicinity of that town. His description of

Of Aix.

the bricia of Aix, in fact, corresponds with the present, as presenting grey, brown, and red spots, on a yellowish base. The same remark may extend to his bricia of Marseilles, which is reddish, with white, grey, and brown fragments; and which, he adds, is much used and highly esteemed at Paris; where it is unaccountably called *bricia of Memphis*. It is surprising that Saussure, who has described Aix and its vicinity, has not indicated this singular marble, which was so worthy of his attention in every point of view.

Of Eygliers.

Another singular French marble is the pudding-stone of Eygliers above Mont Dauphin, on the right bank of the river Guyl. This is composed of pebbles chiefly white, grey, and yellow, joined by a reddish cement, and receives the finest polish. Beautiful tables of this marble may be seen at

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[*] P. 341.

Grenoble; and inspection must verify whether the pebbles have been rounded by friction, or the whole be an original rock of a particular crystallisation.

Others.

Another marble, called a violet bricia by the French, comes from Seix and other places in the department of Arriège, which is particularly rich in beautiful marbles. It is a coarse brown, spotted with lilac and white. That of St. Romaine, in the department of Cote d'Or, so styled from the excellent wines of Burgundy, is of a brick red with angular fragments of yellow. Doulers, in the department of the North, presents a bricia of many fragments, ash colour, white, and reddish. That styled of the Pyrenees, is of a brownish red, with black, grey, and red fragments, and has considerable reputation.

Of the common kind, Saussure has observed the following examples:

The mountain near Vevey is composed of coarse pudding-stone, the rounded flints being united by sand, and this sand by a calcareous gluten, which, in the rents and intervals of the beds, assumes the form of spar.

The pudding-stone of which Mount Rigi is composed, consists chiefly of red clay pebbles, so soft as to be affected by rain water, and united by a calcareous gluten.

A pudding-stone of fragments of black hornstein in a gluten of clay, iron, and lime*.

The chief specimens have been already indicated.

STRUCTURE II. SMALL GRAINED.

Calcareous sandstones are regarded as common. That of Fontainebleau, which is commonly reckoned calcareous, does not, by Brongniart's account, always effervesce with the nitrous acid; but only that of two quarries, Bellecroix and Nemours, in which the curious crystals are found. The others afford siliceous sandstone.

The sandstones which present zones of different colours, and dendritic delineations, seem to be chiefly argillaceous, the clay cement being impregnated with iron. Calcareous sandstone often alternates with limestone, and is ascribed by many to the same formation. Sites. It is the most common of all the sandstones, and forms long chains of hills, from Osnabruck down to Hessia, and along the Rhine. It also constitutes the base of the Canton of Berne, and rises into considerable mountains in the south of France, particularly that of Caume, on the north of Toulon, which consists of alternate beds of limestone and calcareous sandstone*.

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* § 1099, 1941, 1539.

Of Fontainebleau.

According to Patrin, the sandstone of Fontainebleau is always a calcareous glutenite; but when he praises its utility at Paris, where it is employed in paving the streets, he forgets that it wears out in three years; while granite might be had from Cherbourg, which would last thirty. This celebrated sandstone sometimes forms regular beds, and sometimes only appears in blocks, dispersed in heaps of pure quartzy sand, upon which the gluten does not seem to have acted. For Romé de Lisle has long since remarked, that such sand is often a pure homogenous production of nature, which must not be confounded with those proceeding from decomposition†. The formation of this stone seems illustrated by the noted crystals, which, though composed of quartzose sand, assume the rhomboidal form of calcareous spar; and some even present crystals of a beautiful yellow spar, quite transparent. Perhaps it was in a different quarry, that Lassone made the singular remark, that the new surface, at the end of some months, was covered with a glassy crust of a siliceous nature, arising from some lapideous juice, which remains, as before observed, among the secrets of nature; because stones have never been analysed in their original state.

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* Patrin, iii. 324. He seems singular in his opinion that the building stone used at Paris is a calcareous sandstone, while all others regard it as a konite. See Brongniart, art. *Moellon*, i. 204. It is the *chaux carbonatée grossiere* of Haüy.

† ii. 63.

Even Mr. Kirwan has little enlarged upon the calcareous sandstones. Mr. Jameson has, as usual, employed much labour in illustrating the different formations; but he has not drawn a precise line of distinction between the different kinds; as it is probable, however, that his third formation is chiefly a calcareous glutenite, the following curious observations well deserve a place here.

In columns.

"No rock presents a greater variety of external appearance than this sandstone. Its valleys are deep, rocky, and romantic; its hills conical, steep, and cliffy; and it often presents grand colossal pillars and masses, which, from their number and variety of their shape, form most striking rocky scenes. These hills, pillars, and masses, often reach a considerable height; but their summits are all nearly on the same level. One of the most striking appearances of this kind is at Adersbach, in Bohemia. There we observe numberless cones, pyramids, and pillars, sometimes isolated, sometimes joined together, and from two to three hundred feet high, spreading over a considerable tract of country. In other places, caverns or grottos appear, from which there issue many streams, that give rise to waterfalls, and thus increase the beauty of this striking scene. These caverns are wide at the mouth, but become very narrow towards their further extremity, and are generally very short. This form shows that they owe their existence to external agents, particularly water. A more near examination discovers that the seams of the strata of the different isolated masses correspond to each other; which renders it probable that all these cones, pyramids, and pillars, have been formerly united; and that the perpendicular rents or fissures have given rise to this disunion, which has been afterwards increased by the action of the air, and by the water carrying away the softer or more loosely aggregated parts of the sandstone, and leaving the harder parts in these various forms. A similar appearance of sandstone occurs near Tunis, and, from its striking resemblance to ruins, is described as the remains of a great city, by some travellers who saw it at a distance. In the land of the Namaquas, in southern Africa, and on the banks of the Wolga, there are similar appearances."* This glutenite may, however, be argillaceous.

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* Geognosy, 161. Soulavie, tome i. gives a print of square calcareous columns at Ruons, on the river Ardeche.

In his edition of Linnæus, Gmelin has produced various minute substances, while he ought to have begun this genus with his sixteenth species, as the most important, being the *Quadrum*, celebrated as he says in architecture*. The venerable Wallerius has with more judgement, as usual, described the *quadrum;* so called, as he says, because it often rises in square forms. He establishes its calcareous nature; and says that it is of great use in architecture. He mentions the white, the yellow, the grey, and the red, the latter being from Shropshire. Pott, Vogel, and others, at first supposed this stone to be merely calcareous, and even the sand may in fact be calcareous; but in general, upon leaving a small fragment in the nitrous acid, the quartzy sand will become visible or tangible. A useful observation is, that the nearer to the sea it is quarried, the less it will withstand the weather; as any saline particles attract the humidity, which during frost expands and splits the stone. In like manner if konite be accidentally moistened with sea-water, it will be subject to decay.

In the passage of Fours, near the mountain of

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* He ranks it among the calcareous, though by his description it must be argillaceous. The cement is, however, sometimes of marl, or a mixture of lime and clay.

Bonhomme, Saussure observed a remarkable sandstone, which he thus describes:

Of Form. "All the beds of sandstone observed on this mountain do not contain rolled pebbles; there being irregular alternations of beds of pure sandstone, and beds mixed with pebbles. The most elevated contain none. The highest of those which contain any, is a continued bed of a foot in thickness, and which rises 30 degrees to the N. W.

"Some of these beds, filled with pebbles, present a very remarkable singularity: on their external surface exposed to the air, is observed a kind of network formed of black and saliant veins, two or three inches above the surface of the rock; the meshes of this net are sometimes irregular; but for the most part they are oblique-angled quadrilaterals, whose sides are eight or ten inches long. As these rocks have all a tendency to split in rhomboids, it seems that there have been formerly clefts, which divided the beds in parts of this form; and that these clefts have been filled by sand, which has been cemented by a ferruginous juice: this solid gluten has made these parts harder than the rest of the rock; and when the injuries of the air have attacked the surface of these beds, the meshes of the net have remained protuberant.

"The rounded pebbles, which have been long exposed to the air, have also outwardly assumed a blackish ferruginous tint; but those which are still enclosed in the beds of sandstone have, like that, a yellowish colour. I found none in it which were not of a primitive nature; and the most part were of a very hard grey or reddish felspar, and confusedly crystallised. They are then stones which do not naturally possess a rounded form, and which consequently only receive that they have here, by rolling and the friction of the waters.

"All these sandstones effervesce with acids; but the ferruginous parts of the net much less than the base itself. In like manner, if the sandstones which contain pebbles, and those which do not, are compared, in the former will be found more calcareous gluten, their coherence being much more diminished by acids. On the very summit of the mountain these sandstones are covered by a grey shining slate, which exfoliates in the air; and descending from this same summit, on the N. E., on the opposite side to the passage of Fours, beds of sandstone will be observed exactly similar, and which there divide of themselves in small parallelopiped fragments."*

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* § 790.

Saussure also gives numerous other examples of calcareous sandstones.

Of Vaucluse.

Near Vaucluse, § 1545, are beds of sandstone, composed of angular and round fragments of transparent white quartz, and of yellowish or greenish steatite, semitransparent, in a calcareous gluten.

A sandstone, § 1564, of a red wine colour, inclining to violet, very fine, and spangled with calcareous spar. It makes a warm effervescence with the nitrous acid, leaving a sand of white quartz, and some grains of felspar.

A sandstone, § 1487, composed of grains of quartz, and a kind of red ochre, in a calcareous cement.

The sandstone of Voisy, § 304, consists of quartzy sand, mingled with a little clay, and small specks of mica, all united by a calcareous gluten, which sometimes assumes the form of spar in the interstices of the beds.

Recent formation.

"I have seen myself," says this accurate author, § 305, "on the shores of the Mediterranean, near Messina, and the noted Gulph of Charybdis, sands which are moveable, when the waves heap them on the shore; but which, by means of a calcareous juice which the sea infiltrates at that spot, harden gradually, so as to serve for mill-stones. This fact is well known at Messina; and stones are incessantly taken from the shore, without their being exhausted or the spot being lowered. The waves throw fresh sand into the vacancies; and, in a few years, this sand becomes so agglutinated, that the stones of new formation cannot be distinguished from the ancient."

In § 583, Saussure mentions rocks consisting of alternate layers of limestone and calcareous sandstone, in the mountain of Buet. In the same mountain there is a pudding-stone, composed of fragments of grey and reddish quartz, reddish felspar, and little yellow pyrites, united by a calcareous cement.

The *molasse* of Geneva is a sandstone with a calcareous cement, and a mixture of clay; it is soft and impure. That of Lausanne is one of the hardest and best; it is of a beautiful grey inclining to blue with a calcareous gluten. The mountain of Voirons, two leagues from Geneva, chiefly consists of calcareous sandstone*.

Calcareous sandstone, from Fontainebleau.

The same, from Livonia.

The same, from Gothland, Sweden.

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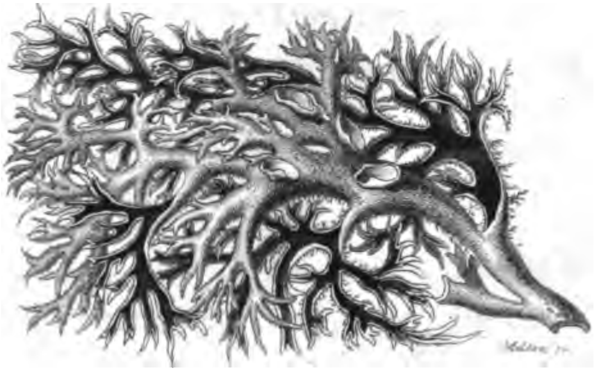
* Sauss. § 61, 1199, 273.

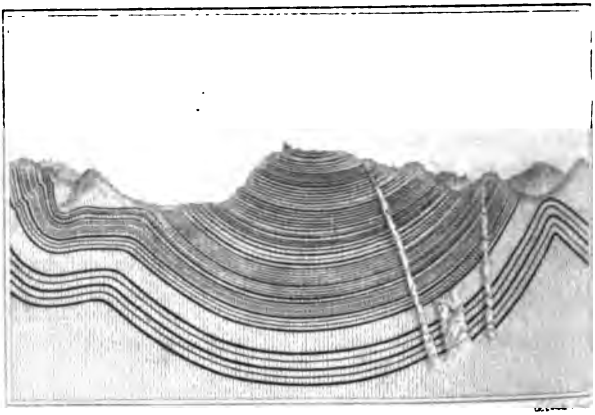
The same, from Swisserland.

The same, with limestone, from the south of France, and various countries.

The same, in red and white layers, from Norway.

The same, of a brownish red with silvery mica, from Metz. That city is chiefly built with this stone.





Hill of St Gilles
near Liege

DOMAIN VI.

CARBONACEOUS.

◆

CARBON.

Name. THE name Carbon is not the most happy, as it arises from charcoal, an artificial substance, while carbon is now well known to be an original element, which exists in the purest state in the diamond, and enters into the composition of siderite, perhaps the most ancient of all the rocks. Charcoal is now regarded as a mixture of carbon and hydrogen. By combustion it is converted into carbonic acid gas, formerly called fixed air, or aerial acid; whence some writers have used the epithet aerated lime, barytes, &c. for what are now called carbonates of lime, barytes, and the like. The discovery of this new air by Dr. Black, led to wonderful improvements and a total renovation of chemistry, which in its present form has been called pneumatic, from its spiritual foundations. It is indeed remarkable, that the profoundest study, and the most patient experiments, should conduct us from matter to spirit; and thence by a natural gradation of thought, to that ineffable spirit, the Creator of the universe.

Carbonic acid.

The carbonic acid gas, more briefly called carbonic acid, forms a constituent part of the atmosphere, in the proportion of about 1, in the 100, while the remainder consists of about 77 of nitrogen and 22 of oxygen gas. Combined with the earths, it forms carbonates: and that widely extended substance called limestone, which is often primeval, is a carbonate of lime.

Carbon itself not only appears in the purest state in the diamond; but forms the preponderant part, sometimes even 90 in 100 of the substances now under view, and which have therefore been called carbonaceous. They not only enter into the composition of rocks, and some even of the primitive, but form rocks themselves, as coal has been found in masses of 80 or 90 feet in thickness. The trivial name of sea-coal, arising from its importation at London, might therefore well be exchanged for that of rock-coal, as we say rock-salt. Some might, perhaps, prefer the German appellation of *bergarts*, implying substances of whatever kind which enter into the composition of mountains; or the Greek *geostromes*, proposed by Patrin, to denote the strata of the earth. But as the conchitic beds of limestone, sometimes more recent than coal itself, though often in thin strata, universally assume the name

Bergarts.

Geostromes.

of rocks, any refined discrimination would appear unnecessary. It has already been more than once observed that the division of mineralogy into three quite distinct and separate provinces, METALLOGY, LITHOLOGY, and PETRALOGY, would be of the utmost importance to the progress, illustration, and utility of the science; each of them being amply sufficient for the life and labours of one man; and, in this case, the subjects under view could not be allotted to any other grand division.

MODE I. GRAPHITE.

Characters. Texture, fine grained, but sometimes coarse, schistose.

Hardness, cretic. Fracture scaly foliated, sometimes slaty and uneven, sometimes rather conchoidal. Fragments amorphous, rather sharp.

Weight, carbonose.

Lustre, metallic. Opake.

Colour, somewhat leaden, which occasioned the vulgar, but very improper, name of black lead.

When pure, it usually contains about 90 parts oxyd of carbon, with 10 of iron; but the foreign kinds are often contaminated with large mixtures of argil and silex, which renders them unfit for the usual purposes of writing and drawing.

Sites. The best is that found at Borrodale, in Cumberland; a mine which has long supplied the world with this valuable article; but the French have lately succeeded in the fabric of an artificial kind. Graphite has also been recently detected in the southern parts of Scotland, with a singular kind of coal, called columnar, because it appears like little basaltic prisms.

It is sometimes of a scaly appearance, which Werner has arranged as a subdivision.

In the perusal of books of mineralogy, every judicious reader must have remarked that, according to the various dispositions of the authors, they are fertile and satisfactory on some topics, and barren on others: whence the great utility of compilation, whose office, from the days of Aristotle and the first dawn of science, has been to collect, and arrange for the universal benefit, facts and observations, which became more valuable from being concentrated. The prince of the Roman poets compares this practice to that of the bee, who prepares her elegant edifice and useful honey from various flowers, some of which only perfume the desert air. This work has, therefore, without hesitation or apology, adopted interesting descriptions from former writers, whether domestic or foreign, but especially the latter; for many excellent works are published which will not bear complete translation, but of which detached portions are highly satisfactory and interesting. Such is the elementary treatise on mineralogy by the ingenious Brongniart, director of the celebrated manufacture of porcelain at Sevres, whose accounts of graphite and anthracite (which will follow in its proper place), are the most ample and satisfactory which have yet appeared.

Brongniart's account.

"Graphite is of a grey almost black, with a metallic lustre; it is soft, smooth, and even unctuous to the feel; its fracture granular; it leaves distinct marks on paper, clear, and of a bluish black; it even leaves marks on vitreous surfaces, such as earthen-ware: its marks are grey, while those of sulphuretic molybdena, which much resembles it, are greenish.

"Its specific gravity is from 2,08 to 2,26. It consumes and volatilises under the blow-pipe, by a continued heat. Nitre renders its combustion quicker and more sensible.

"Slightly rubbed on resin, it does not communicate any electricity to it, while it leaves a kind of metallic coat.

"This substance, according to the experiments of Mess. Berthollet and Monge, is composed of iron and carbon, in the proportion of 0,90 of carbon and 0,09 of iron. The iron is in too small a quantity to rank graphite among the iron ores.

"1. *Laminar Graphite.* It is found in lamellæ, or rhomboidal, or hexagonal spangles; it is of a tin-white.

"2. *Granular Graphite.* It is in mishaped masses, or compact lumps, with a granular fracture, the grains more or less fine.

" Graphite seems to belong exclusively to primitive regions: sometimes it enters into the composition of the rocks which form those regions; sometimes it is found in masses, or in considerable layers. It is likewise met with in beds of argillaceous schistus.

" It is found:—in France, in the department of Arriège, in large compact masses; in the department of Mont Blanc; in that of Sture, near Vinay, above the baths; in the mountain of Lubacco, and in that of Gogni d'Orgial, in small veins in granite. In the valley of Pellis, district of Pignerol, department of the Po, in veins of a yard in thickness, in granitic rock (Bonvoisin). In Spain, near Sahun, district of Benabarra, in the mountains of Arragon (Parraga), and near Casalla and Ronda in the kingdom of Grenada. In Bavaria: in Norway near Arindal; this is the laminar variety. In England, at Borrodale, two miles from Keswick in Cumberland, this is the most celebrated graphite mine; pencils of an excellent quality are made of it, and recommendable, as being at once firm and soft. The bed of graphite is in a rather high mountain, between layers of a slaty schistus, crossed with veins of quartz; the bed or vein which it contains, is nearly three yards thick; the graphite is there found in large masses, but of different degrees of quality; what is not good, is thrown away.

" Pencils, which are enclosed in cylinders of wood, are made of graphite. In France they are called *mine de plomb*, or capuchines. The pieces of graphite are sawn in very thin quadrangular sticks, which are put in a groove made in one of the halves of the wooden cylinder, which is to form the envelope of this fragile pencil.

" The dust of the graphite, mixed with gum, forms pencils of an inferior quality.

" This same dust serves to lay over iron, and especially cast iron, to keep them from rust; mixed with grease, it is used very efficaciously to diminish the frictions in wheel engines.

" Also, mixed with argil, at Passau in Germany, they make crucibles of it, which resist extremely well sudden transitions of temperature, and which are used by smelters.

" Laminar graphite is often formed artificially in the flaws of cast iron, and in the cavities of furnaces where iron is used. M. Fabroni affirms that it is also sometimes formed in the humid way; and cites, on this occasion, the pits dug in the territory of Naples: an acidulous water is collected in them, at the bottom of which, graphite is gathered every six months."*

Our ingenious author is mistaken, when he says the graphite of Cumberland is found between layers of a kind of slate, traversed by veins of quartz. Several specimens of the rock are now before me.

Graphite of Borrodale.

1. Nodules of graphite in the rock itself; which appears decomposed, and in some parts tinged with oxyd of iron, arising from the partial decomposition of the graphite. The stone easily yields to the knife, and is of a bluish grey colour mottled with white. It has an unctuous steatitic appearance, and seems to be a decayed serpentine.

2. The same rock, at a further distance from the mineral, and undecomposed. This seems a Saussurite, or magnesian basaltin. It is of a deep grey colour with dots of light brown, which may be a decomposed felspar; and is mixed with large patches, which approach the nature of indurated steatite, of a light greenish grey, mottled like the decomposed substance which contains the nodules. It is, upon the whole, a magnesian rock, of a particular description, with a stong argillaceous smell, in this and other

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* Brongn. ii. 53.

characters approaching to some serpentines; for that peculiar odour does not arise from the argil, as commonly supposed, but from the iron contained in the argil, and therefore expires from many rocks not argillaceous. It is worth observation, that serpentine has never been observed to contain any metal except iron, and its relatives pyrites and garnet; so that it is not surprising that it should contain graphite, or carburet of iron. Perhaps the superiority of the English kind may be owing to this circumstance, the unctuous nature of the rock imparting that quality to the mineral; as common flint becomes menilite, from the unctuous and magnesian marl in which it is deposited.

Another rock is found at Borrodale, I know not if in contact with the former, but it appears somewhat allied from the structure and nodules. This seems to be a magnesian felsite, of a dark grey colour, dotted with little reddish crystals, and with greenish nodules. It is well known that the British rocks are often anomalous, or transilient, and can scarcely be reduced to precise denominations, till the science shall have made a far greater progress than it has at present.

Of Chamouni. Saussure discovered graphite, which, with the writers of that time, he calls *plombagine*, on schistose quartz, among the Alpine fragments in the valley of Chamouni; but upon reaching the rocks, it only formed a kind of gneiss; being thin plates of graphite interposed between layers of quartz, thus assuming as it were the place of foliated mica.

STRUCTURE I. MASSIVE.

Aspect 1. Fine. From Borrodale, near Keswick, in Cumberland.

The same, in nodules in the rock already described.

The same, as found with columnar coal, from Scotland.

The same, from the north of Italy, France, &c.

Aspect 2. Coarse. This is commonly mixed with silex, argil, and other impurities.

From various parts of France and Germany.

STRUCTURE II. LAMINAR.

With laminar quartz, from the valley of Chamouni.

From Arindal, in Norway.

Laminar graphite, interposed at certain intervals in gneiss, from Greipon, in the Alps. Communicated by Gillet Laumont.

MODE II. ANTHRACITE.

Characters. Texture, schistose and incoherent.

Hardness, cretic. Fracture, slaty. Fragments, amorphous, rather sharp.

Weight, carbonose.

Lustre, sometimes dull, but generally glistening and even metallic. Opake.

The colour is often a dark black, but sometimes has a metallic reflection, which is particularly conspicuous in that elegant kind called Kilkenny coal; and which might with much **Kirwanite.** propriety be called Kirwanite, in honour of the great Irish mineralogist, who first introduced it to scientific attention. The French continue, most unaccountably, to confound it with canel coal, which is quite a different substance*.

Anthracite seems to have been first observed by Dolomieu; but Born, in his elegant catalogue of Miss Raab's collection of minerals, has classed it under graphite, which he calls *plombagine*, or carburet of iron, in the following terms. It must not at the same time be forgotten, that Pliny uses the word *anthracites*, in a very different sense, for a gem which has the effulgence of burning coal.

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* In order to obviate this error, the author, among many other British substances, placed specimens of Kilkenny coal in the museum of the *Jardin des Plantes*, and another great collection at is.

" Coaly Plombagine. Anthracolite.

Born's account.

" This kind of plombagine has recently been discovered at Schemniz, in Hungary, which differs from the known plombagine, as being very light, compact, brittle, of a shining and conchoidal fracture, and without soiling the fingers is easily broken. It has but very little iron in its mixture, and therefore when calcined under a muffle, slowly dissipates, and loses 90 parts of its weight. According to the analysis, lately made at Schemniz, in Hungary, in 100 parts there are 90 of carbon, 5 of argil, 3 of iron, and 2 of silex.

" It seems to have some affinity with the incombustible pit-coal, described by M. de Morveau in the new Memoirs of the Academy of Dijon. *Prem. Semest.* 1783, page 76—86.

" Mr. Struve has just given the description and analysis of a fossil, which, with the exception of the colour, still more agrees with this variety of plombagine. He calls it also coaly plombagine. See Journal de Physique, 1790, January, p. 55.

" Black compact coaly plombagine, with

a shining fracture; of Pacherstolln at Schemniz, in Hungary.

"It adheres to a blue argil, greyish, mixed with pyrites. The vein, in which it is found, is filled with this argil, which is only a decomposition of the metalliferous rock. It is in this argil that different sized pieces of this coaly plombagine are found, which for the most part have a cylindrical form. They even seem to be composed of concentric layers round a kernel; in short, this plombagine nearly resembles wood, and to all appearance has a vegetable origin."

Of the Alps. Estner also agrees in the wood-like appearance of this anthracite. Among other rocks presented to me by Gillet Laumont, are different specimens of anthracite, which he says is also called *houille sèche*, or dry coal. There is particularly a specimen of that mentioned by Dolomieu, as belonging to primitive regions, and containing no traces of vegetables, from little St. Bernard, in going to the fort in the Alps. This is accompanied by the following specimen and note: "Vegetable impressions, which I first discovered in 1803, serving as a roof to the same anthracite, or dry coal, the wall or under-rock being also a schistus. I had one very fine, with little ramified plants, and another with reeds. A little impression is on this specimen; but the finest are in the cabinet of the Council of Mines." Another specimen of anthracite is from Allues, Mont Blanc; and a third, which is slaty, is from Regny, near St. Simphorien de Laie, on the road from Roanne to Lyons.

The best account of anthracite, as already mentioned, is that given by Brongniart, which shall therefore be translated.

Brongniart's account.

"Anthracite so much resembles coal, at first sight, that for a long time it was taken for a variety of that combustible mineral. Nevertheless, artisans who used it had remarked, that it burnt with great difficulty, and did not produce either that white flame, or black smoke, or that bituminous odour which arises from coal; therefore it was called, incombustible pit-coal.

"Anthracite is of a black less opake than coal; its colour approaches nearer by its brightness, to the metallic black; it is also more friable; it is rough to the touch, and easily stains the fingers; it leaves a black mark on paper, which, if examined with attention, seems of a dull black. These characters serve to distinguish it from graphite, which leaves a bright mark, and is unctuous to the feel.

"The texture of anthracite, sometimes schistose, sometimes compact, at others granular, is too various to serve as a characteristic. Its specific gravity, which is 1,8, is inferior to that of graphite, in the proportion of 9 to 14; and exceeds that of coal, as 9 to 7.

"This mineral is decidedly opake, it easily allows the electric spark to pass, is hard to burn, and in its combustion never produces but one substance, which is carbonic acid.

"The matter essential to its composition, is mixed carbon; or perhaps combined sometimes with silex and iron, sometimes with argil and silex in very different proportions, according to analysed specimens.

"1. *Friable Anthracite.* It is in mass, granular, not schistose, greatly soiling the fingers, and easily crumbles.

"2. *Scaly Anthracite.* It divides into large solid scales, the surface of which is unequal, undulated, and shining; it soils the fingers less than the preceding.

"These two varieties are found at the villages of Arrache and Macot, in the neighbourhood of Pesey, department of Mont Blanc.

"3. *Schistose Anthracite. (Haüy.)* It divides into laminæ, with an uneven and undulating surface.

"4. *Globular Anthracite. (Haüy.)* It is found in small globular masses, in crystallised carbonate of lime, at Kongsberg in Norway.

" Anthracite is often found in primitive regions, which is a remarkable circumstance in a combustible which seems so nearly allied to coal. It generally is found in mica-slate, and even gneiss; it is sometimes in beds, sometimes in veins. Its layers are often winding and contorted, like those of the rocks with which it alternates.

" Dolomieu saw anthracite in veins, in the porphyritic mountains near Chapelle, department of Saone and Loire. In the Tarentaise of Savoy, it contains 0,72 of carbon, 0,13 of silex, 0,03 of argil, 0,03 of iron, and 0,08 of water. Primitive anthracite is found in Piedmont, at the foot of little St. Bernard. In the department of Isère, in lumps or heaps, in the midst of a pudding-stone, composed of primitive rock, and without any vestige of organised bodies. At Musy, near Clayte, in the former Charolais. At St. Simphorien de Laie, in the environs of Roanne. At Diablerets, in Valais.

" M. Ramond has mentioned an interesting variety, which he found at the bottom of the valley of Heas, the upland of Troumose, department of Upper Pyrenees, in the midst of mica-slate. This anthracite disposed in veins, only contains carbon, mixed with a small quantity of silex and argil, there not being any iron. This circumstance fully distinguishes anthracite from graphite.

"M. Fleuriau de Bellevue has found anthracite crystallised in regular hexaedral plates, on a granitoid, which is found in isolated blocks on the quays of Saardam, in Holland*. It is thought these rocks have been brought from Norway. This anthracite, according to M. Vauquelin, only contains carbon, silex, and argil.

"Anthracite is also mentioned in the neighbourhood of Schemnitz, in Hungary, in a vein. At Kongsberg, in Norway, it is mingled with native silver. In Spain, in the port of Pajarés, which separates the kingdom of Leon from the principality of the Asturias, it reposes on a clay-slate; and, according to M. Proust, contains 0,93 of carbon, and 0,07 of sand, argil, and iron. It is used in painting, the same as lamp-black. (D. B. Canga-Arguelles.)

"Anthracite is not exclusively found in primitive regions. M. Héricart-Thury has shown that that which is found in the department of

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* In the curious collection of rocks formed by the venerable Besson, formerly director-general of the mines of France, the author was surprised to find numerous specimens from Zealand; and the possessor has even adduced them as such in his printed works. They were from ballast thrown on the quays of Zealand. The quays of London furnish many curious rocks.

Isere, near Allemont, towards the summit of the mountain of Challanches, at an elevation of 2563 yards, is secondary. It lies between two beds of black schistus, covered with impressions of vegetables; it contains no bituminous matter, and has 0,97 of carbon, so that it is nearly pure carbon. That of Rousses, opposite the same mountain, and that of Venose, near the village of Oysans in the same valley, are also of secondary formation. The anthracite of Lischwitz, near Gera in Saxony, is in layers of clay-slate, covered with vegetable impressions. (Roemer.)

"The anthracite which contains no indication of vegetable coal, is wholly incombustible; that which contains any, may burn, if two-thirds of charcoal be added to it. (Héricart-Thury.)"*

Brochant observes, that if anthracite be held a long time on fire, moving it often, it consumes slowly without any flame; but only encircled with a little glory, or irradiation, like red iron and diamond. During this operation it loses about two-thirds of its weight, and the residue is of a blackish grey, which announces that the combustion is imperfect.

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* Brongn. ii. 56.

It is worthy of remark, that as anthracite has been found in a primitive glutenite or pudding-stone, so the usual gangart of diamonds, both in Hindostan and Brazil, is a ferruginous pudding-stone. The author has had the satisfaction of seeing one of the Deccan in the gangart, the pebbles being an unctuous quartz approaching to chalcedony, as in the singular sandstone of Egypt; but some seemed impregnated with iron, so as to bear some appearance of imperfect light brown jasper. A little fragment seemed to be siderous slate.

Anthracite is by Mr. Kirwan called native mineral carbon. He observes, that the kind found at Lischwitz, in extensive strata, and that of Strido in Tuscany, are among the most pure. Kilkenny coal. He rightly classes the Kilkenny coal as an Anthracite; and, by his analysis, it must be one of the purest, as it contains no less than 97 of carbon. But it seems of a different structure from the anthracite found on the continent, having a far more compact appearance, with a metallic lustre at once more bright and steady; nor is it so brittle, nor so ready to stain the fingers. What is called the culm of Wales by Mr. Kirwan, and which he regards as a variety of this Swansea coal. species, is probably the Swansea coal, of which some kinds have a singular and highly metallic lustre, approaching even to some iron ores of Elba.

STRUCTURE I. ANTHRACITE.

Aspect 1. Compact. From Alliers, Mont Blanc.

From little St. Bernard, accompanied by fine slate with vegetable impressions.

Aspect 2. Laminar. From Regny, near St. Simphorien. Other sites of both kinds are above mentioned; that of Kongsberg, in Norway, mixed with native silver, being among the most interesting.

STRUCTURE II. KIRWANITE.

The chief differences of this structure have been already mentioned. Mr. Kirwan observes, that when fresh broken it frequently appears of a violet colour. Its lustre he estimates at 4, or metallic; while that of anthracite is from 3 to 4 approaching metallic. The fracture is foliated, but the course of the plates variously, confusedly directed, as in some kinds of common coal. Its fragments are often coated with whitish illinitions;

it will not burn till wholly ignited, and then slowly consumes without caking or emitting flame or smoke. The ashes are reddish and few.

Our learned author unaccountably omits the nature of the rock and gangart; nor does he repair the deficiency in his geological essays.

Aspect 1. Kirwanite from Kilkenny.

The same, with the gangart and specimens of the incumbent rocks.

Aspect 2. The Swansea kind also burns very slow, without flame, and yields a strong and lasting mass of heat, with a glowing colour. Swansea is in the county of Glamorgan, South Wales, in a more southern latitude than Kilkenny.

Kirwanite from Swansea.

MODE III. COAL.

Sites.

This useful substance, which may be said to form the gold mines of England, is not only particularly abundant in the British dominions, but widely diffused over many parts of the world. The Netherlands and France seem to follow Great Britain in this mineral wealth; but it also appears in the north of Italy, and various parts of Germany, as Silesia and Hessia*. It has been used in the north of China from time immemorial, and is not unknown in Japan. Its discovery in Australasia would add little to the advantages of a new country abounding in wood. Concerning the coal of Africa, nothing seems to be reported. In the territory of the United States of America, coal is said to abound on both sides of the James river, but particularly in Virginia, and towards the Ohio. In the isle of Cape Breton there is an extensive bed of coal, which is chiefly used for ballast.

Ancient use.

Coal appears to have been anciently known, not only in China, but in other countries. Solinus * evidently indicates the use of coal, when, mentioning the medical waters at Bath, he says they are dedicated to Minerva, " in whose temple the perpetual fire does not leave embers, but is changed into rocky lumps." This pretended miracle was the natural progress of a coal fire, caked into hard cinders, instead of the soft embers of wood. The abundance of coal in the neighbourhood of Bath also favours this supposition. Nay, Theophrastus mentions that the smiths of Greece sometimes used a black stone for their fires, which must have been coal †. In England it seems to have been in common use in the twelfth century; but still more early in Flanders.

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* There is a mine of excellent coal in limestone, in the hill of St. Gingoulph, near Geneva, pronounced, as Saussure observes, § 324, St. Gingo, probably the source of a ludicrous oath in England, because the first reformers were educated at Geneva.

Coal forms prodigious strata, generally rather descending than rising; but the hill of St. Gilles, near Liege, may be said to be chiefly composed of coal, of which there are not less than 50 or 60 strata. The deepest mines known, are said to be those of the country of Namur, some of

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* Cap. 25.

† He says it was found in Liguria, as was amber, and also in Elis; and he speaks of its use as common among the smiths. For that of Liguria, see Mode iv. Gagas whence the name of jet, as first found there, was near Chimera, probably a pseudovolcano, arising from inflamed coal.

which descend two thousand four hundred feet, or about half a mile. The semidiameter of the globe is about 3500 miles; so that our knowledge, comparatively, would only extend to the outward texture of the paper, of a common globe three feet in diameter.

Soils.

Mr. Kirwan has, with his usual accumulated reading, discussed the various soils in which coal appears; but an enumeration of the different beds of clay and stone, would little interest the general reader, while the scientific may consult his work*. The beds which immediately cover coal, and are thence called its *roof*, are shale, (a kind of clay-slate,) and argillaceous sandstone. Both contain impressions of vegetables, generally such gigantic ferns and reeds as at present astonish the traveller in the tropical regions. The strata on which coal reposes, which are thence called *floor*, *sole*, or *pavement*, are sometimes shale, or indurated clay; but more frequently sandstone; and often the red ferruginous kind, which is esteemed most ancient. The shells are chiefly those of rivers, and seldom those of the sea. It is now well known, from the experiments of Mr. Hatchet, that this substance is of vegetable origin; and it is a singularity, but upon which no general theory can be constructed, that the chief beds of coal occur near the mouths of great rivers, and in a kind of proportion to their relative size. Thus the immense Rhine, which seems, like many other powerful streams, to have more than once altered its estuary, has in its vicinity rocks of coal at least 80 feet in thickness; while more moderate strata are found near the Rhone, the Clyde, the Forth, the Tyne, the Severn. In some instances the form of the coal district is that of an isosceles triangle, the vertex being towards the sea. In savage countries, darkened with immense forests, and where wood is only a superfluous weed, the quantity of trees overturned by age, tempests, and inundations, exceeds all imagination. On the Missouri, there is said to be a bridge, not less than three miles in length, formed by successive trunks of trees, which have been stopped in their progress; and the soil near its mouth may be said to be formed of alternate strata of timber and mud, which may probably become coal and shale, for the use of nations to be born, after a period of many thousand years, and who, perhaps, may faintly trace in their annals some memory of a celebrated ancient nation called Britons.

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* Geol. Ess. p. 290.

But this is merely an excursion of theory, and igin of coal is far from being precisely ined. It occurs in such places, and with such circumstances, as, like the other works of nature, seem calculated to confound the faint light and puny pride of human reason.

Patrin's remarks.

Patrin, with his usual ingenuity, enumerates some of the most striking features, which accompany this important formation.

" Many similar circumstances every where accompany beds of coal.

" 1. It is known that this deposit must have been made in still water, and that it has been found on the sides of the soil which has served it for base. In general, beds of coal have their extremities even with the ground, they descend obliquely; they assume in their depth nearly a horizontal position, afterwards to ascend on the opposite side; so that by taking away, in idea, all the soil which covers them, they will be found to have nearly the form of a boat: it has been remarked also, that they are thicker at their depth than at their ends.

" This disposition is manifest in a great number of mines, and especially in the vast coal mines in the neighbourhood of Liege.

" 2. A bed of coal is never single: at Whitehaven in England there are 20, one above another; at Liege there are reckoned 60[*]; three or four are most commonly found, and in general of nearly an equal thickness.

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[*] At Gilmerton, near Edinburgh, there is the same number. Williams, i. 41.

"3. Each bed of coal is separated from the others by several rocky strata, which are nearly the same in all coal mines.

"Those which form the roof and the wall, are always of a schistose argillaceous substance, a kind of friable schistus, almost always sulphureous: afterwards follow strata of micaceous sandstone, which seem derived, at least in part, from the *detritus* of the primitive mountains of the neighbourhood.

"These strata of sandstone are often separated by small schistose layers, which contain some symptoms of coal; they are both often repeated between two beds of coal.

"It is a general observation, and almost without exception, that the schistose layers, and especially those which serve as a roof to the coal, bear impressions of vegetables, particularly *capillaria*, ferns and reeds, for the most part exotic. This circumstance has led several naturalists to think, that coal itself is composed of the remains of vegetables; but this opinion appears to me to present great difficulties *."†

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* "One of the facts, which is most opposite to it, is the observation made at Santa-Fe-de-Bogota, by the naturalist le Blond, who

† Patrin, Min. v. 317.

Some select observations concerning coal may be added from various authors.

By Mr. Kirwan's experiments coal commonly consists of about 60 carbon and 40 bitumen*.

Structure.

Though coal has never been found crystallised, it seems to split into regular cubes; and another singularity in its structure has recently been observed, that between the layers of a bright bituminous appearance there are thin plates of a velvety lustre, bearing a strict resemblance to charcoal. Coal sometimes contains in little cavities, crystals of calcareous spar, perhaps infiltrated from incumbent limestone. These crystals, towards their summits, present little black zones, arising from the coaly impregnation. Galena, or sulphuret of lead, is also found in the coal of Buckinghamshire. Pyrites are common in most kinds of coal; and, perhaps, the beautiful iridescent illinitions, which in some rare in-

Metals, &c. in coal.

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informs us that beds of coal are there found at an elevation of 13,200 feet perpendicular. When the ocean reached such a height, there would be above its level but a small number of islands scattered over the face of the globe; and it is not any how seen, how the small quantity of vegetables, which had been accidentally brought from these summits of mountains, into this immense ocean, could have formed the thinnest bed of coal, or even of simple turf."—Is not this coal of Santa-Fe anthracite?

* Bitumen long retains its properties. That found on the bricks of Babylon, where it was used as a mortar or cement, still burns, as Mr. Parkinson observed, with a strong bituminous scent.

stances equal all the colours of the richest gems, may arise from the iron and sulphur, as they greatly resemble those of the beautiful ores of Elba.

Oxyd of copper has also been found in coal at Schemnitz in Saxony; cinnabar in that of Idria; native silver in that of Hessia; nay, gold decorates the coal of Reichenstein in Silesia. It is also said that antimony is found in that of the isle called Bras d'or, near Cape Breton in America *.

Werner's arrangement.

Werner has arranged one species of coal under his genus graphite, namely the glance coal; which he again subdivides into the conchoidal and the slaty. *Glance*, applied in the German sense to some ores, and a kind of coal, implies that they have a peculiar bright lustre; and his glance coal with the colour of tempered steel, or a bright variable blue, and which burns without flame or smell, is the same with that found at Swansea, here arranged as a structure of anthracite; for it has neither the appearance nor chemical character of graphite. The slaty glance coal of Werner, the *kohlenblend*, or coalblend of other German mineralogists, is the anthracite. To such inconsistencies have the forced and unnatural application of genus and species, to inert matter, reduced even the ablest authors.

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* Brongniart, ii. 10.

Of common coal, Werner numbers two species, the *black*, and the *brown*.

Black coal.

The *black* coal contains six subspecies; 1. Pitch coal; 2. Columnar coal; 3. Slaty coal; 4. Cannel coal; 5. Foliated coal; and 6. Coarse coal. The first is *jet* which belongs to lithology; the second which burns without flame or smell, is an anthracite, as Voigt allows, and is merely a rare variety. But from the want of judgement in distinguishing between the grand and important substances, and those which are merely trifling and rare varieties, sometimes only exceptions or excrescences, the very arrangement of mineralogic systems is often the source of unnecessary embarrassment; the separation of the pretended species being sometimes radical and essential, and often of the most trifling and ambiguous nature; nay, sometimes as ridiculous as if the species of trees were to be estimated by the mosses which grow upon them, the fantastic forms occasioned by accident, or the cavities hollowed by the hand of time.

The third *subspecies*, which in this barbarous system follows jet, a rare and precious substance, and columnar coal which is confined to one hill, the Meissner in Hessia, is that called *slate* *coal*, which is that substance universally known by the sole name of COAL, which is diffused in vast exuberance through half the globe, and supplies nations with necessary fuel and opulent manufactures! This instance of want of judgement may be added to numerous others already observed by Mr. Chenevix *.

The fourth *subspecies* of Werner is *cannel coal*, so called from the enunciation of the word *candle*, in Scotland and the north of England, because its flame is clear and pure, like that of a candle. By many French writers, and even by Brochant and Brongniart, it has been strangely confounded with *Kilkenny coal*, which being an anthracite emits no flame; a clear distinction, indicated by the simplest chemistry of nature. It is not only found in several coal mines of the north of England, but in those of Gilmerton near Edinburgh. When very pure, it is made into various little vessels, snuff-boxes, and ink-holders. The Roman writers mention jet, as a chief mineral product of Britain, and some suppose that the cannel coal is intended, but it would rather appear to be the real jet found on the eastern coasts, particularly that of Norfolk, and which, as the substance is merely bituminous wood, may either proceed from parts of the submarine forest, recently observed on the coast of Lincolnshire: or, as it is very light, may be brought by the sea from a great distance.

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* See his Critique on the Wernerian system, in the *Annales de Chimie*, 1809.

The fifth *subspecies*, the *foliated* or *laminar*, is found in the Electorate of Saxony, and in Silesia; but it may certainly be observed in almost every coal pit, as in fact almost all coal may be said to be slaty; nay, Werner has arranged it himself under that subdivision. The last, and very important *subspecies*, is *coarse coal*, which, forsooth, has been found in the coal works near Dresden! It is too well known to many of my readers, and rather too abundant on the London wharfs. By such sagacious subdivisions, an impure gold must be regarded as a different metal.

It may, perhaps, be satisfactory to complete this brief view of Werner's coal, which, like the magical mirror of Dr. Dee, formed of cannel coal, represents spirits and species of all kinds and dimensions, with some account of his other division, that of *brown coal*, which contains five *subspecies*. 1. Bituminous wood; 2. Earth coal; 3. Alum earth; 4. Common brown coal; and 5. Moor coal.

Brown coal.

The *first* is an important and widely diffused substance which may be said to form rocks, or rather mountain masses, by the Germans called *Bergarts*; for as rocks may be formed of shells and other animal substances, so they may be constituted of the venerable remains of primeval vegetation. This kind is the *Bovey coal* of England; and in the Prussian amber mines is found with adhering amber. It is the *Surturbrand* of Iceland where it abounds; and is diffused through many parts of Germany, France, Russia, Siberia, and other grand regions of the world.

The *second* subspecies, *earth coal*, is sometimes found with the former, being merely bituminous wood more decomposed. The *third*, or *alum earth* is certainly a most capricious alteration, as he had formerly and properly arranged it among the argils, and it ought in lithology to stand at the very head of that class. It may have been used as a fuel, as orsten is in Ireland; and, perhaps, Mr. Werner may, in his annual almanack of classification, arrange that limestone among the coals. The fourth *subspecies*, *common brown coal*, is, by Mr. Jameson's own account, the same with the first or bituminous wood, being found at Bovey, and in Prussia, with amber; so that it can hardly be called a variety, certainly not a diversity. The *fifth*, or last *subspecies*, that of *Moor coal*, is again a mere variety of bituminous wood, but more brittle, as it is mingled with reeds.

The author must confess, that when he had perused Werner's account of the coals, his ideas of the subject were far more confused than ever they were before; so that he seemed with great study to have learned ignorance. This effect must necessarily arise, when subjects of the utmost importance, and of the most trifling minuteness, are presented to the mental eye, as of equal magnitude. By the unhappy microscope of external characters, an insect may appear like an elephant; while common sense and chemistry can alone present the objects as they really are. It is the chief, if not the only, use of systems in natural history, to assist the memory; and for this purpose, that the faculty may not be strained and overpowered, it is the office of a judicious arrangement, to present the chief objects in the fore-ground, while the others are marked at gradual distances, that the mental eye may repose, as upon a landscape, painted by a master artist.

Soils.

But to return to a more immediate view of the subject. It is not a little remarkable that different qualities of coal are found in different strata of dissimilar rocks, thus confirming an observation already made, that the quality of mineral substances is often influenced by their gangarts. Mr. Kirwan has observed, and he has illustrated the observation by many examples, that the soils containing coal are chiefly clay and sandstone, often both together; which are followed by the rarer instances of coal found under trap or basaltin, which may also assume the form of amygdalite; or, by the coarseness of the particles, become a basalton or grunstein. Thick beds of coal have also been found amid the strata of limestone. As the theme is of great importance to national and individual wealth and prosperity, it may be proper to subjoin the brief general view by Brongniart.

" The coal regions follow in general the same order of composition. 1. Psammites (micaceous and ferruginous sandstone, with a cement generally of argil,) often large grained: they are not only composed of quartz and mica, but of fragments of all kinds of rocks, particularly of felspar. 2. Argillaceous and micaceous schisti; presenting on their plates impressions of fishes and vegetables, which generally belong to the families of ferns and grasses. 3. Beds of marl, carbonated lime, or indurated clay. 4. A kind of secondary argillaceous porphyry, which contains branches, roots, and even entire petrified trees. 5. Argillaceous iron ore. 6. Rolled pebbles enveloped in ferruginous sand." * He afterwards observes, that the limestone which contains coal, often becomes black from inhalations of the bitumen, while the inherent shells are of a white colour.

Slips or dykes.

A remarkable circumstance in coal mines is the frequent occurrence of what our miners call *slips* or *dykes*, while the French call them *creins* or *failles*, consisting of indurated clay, basaltin, called *whin* in Scotland, and sometimes of sandstone. These are sometimes of great extent, and a whin-dyke is said to pass across the estuary of the Forth, from East Lothian to Fife, a distance of 10 or 12 miles. These slips intersect the strata of coal, almost at right angles; and generally derange them, in regard to elevation, the stratum of coal being higher and lower on the different sides of this interruption. It seems a general observation that the strata always sink, on what may be called the back of the slip, which seems to indicate that the matter was ejected from beneath, and that the consequent cavity had occasioned the subsidence on that side. These slips sometimes contain fragments of coal †. They appear in the section of the noted hill of St. Gilles, near Liege. Gennetè has inferred that there are in this hill not less than 61 beds of coal which are salient, or in the mining language *rise to the day*, at distinct distances, but only 23 are worked. The coal mines of Anzin, near Valenciennes, described by Daubuisson, present singular large zigzags which seem to defy all theory, except the prodigious power of steam, arising from internal fires and waters, and acting while the beds were yet soft.

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* Min. ii. 6.

† Near the slips the quality of the coal changes; it sometimes becomes iridescent; still nearer it splits and is friable; then be-

Coal mines of England.

The limits and nature of this work do not permit a description of the important coal mines, even of England. Those of Newcastle are the most celebrated, as they have supplied the capital for many ages. The land which covers these mineral treasures, is often fertile, and lies on an argillaceous sandstone, which forms excellent grindstones, not only common in England, but exported to other countries. Even the roads are grand monuments of human industry, the traveller being astonished to see large carts loaded with coal, proceeding without horses or guides, on wheels adapted to wooden ways defended with iron. The coal mines of Whitehaven, on the western coast, are the more remarkable, as

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comes dull, earthy, and, as it were, identified with the slip. J. des Mines, No. 13, p. 59.

they are continued for a space of more than 1200 yards, or two thirds of a mile under the sea; a situation like that of a mine in Cornwall, where the raging waves are heard over head, most terrible to the imagination. The most celebrated coal mines of France are those of St. Etienne, in the department of the Loire, which have been worked for many centuries. Those of Flanders are also of ancient reputation: and, perhaps, our attention to this valuable substance was, like many other useful improvements, derived from our commerce with the Flemings *.

Even in the same bed the coal is seldom of the same quality, or homogenous; so that many of the German subdivisions would, in the case of any other substance, be regarded as mere varieties. Such is the fibrous coal of Estner, which was brought from Newcastle; the ribbon coal of Irvin on the western coast of Scotland; the parrot coal, said by some to be so called from its iridescence, while others suppose that it received its name from the crackling noise it makes when first kindled. It is surprising that Werner has not arranged the earthy coal, called *smut* or *culm*, as a distinct subspecies. It has been observed, that where the coal approaches the slip, it has lost its bitumen, whence it is argued, that the slip rose heated from beneath; while others only infer, that the bitumen has been absorbed by the humid rock. In confirmation of the former opinion, it is added, that in the north of Ireland the layers of flint become red and light when they approach the whindyke; and specimens which I have seen, certainly bore every mark of having been affected by great heat.

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* According to Buffon, Min. i. 478, 4to. the deepest coal mines are those of Namur, 2,400 feet.

Iridescent.

The iridescence of coal often penetrates a large mass, and appears in almost every direction. In the peacock coal of Wales or Somersetshire, this iridescence often assumes a strong resemblance of what are called the eyes in a peacock's tail*. In that of the valley of Llangolen, the iridescence consists of steel-purple, crimson, green, yellow, and blue, disposed in zones. But by far the most beautiful of this kind, is a coal found in small portions, near Valenciennes, in which crimson, green, blue, and yellow, perfectly opalise or interchange; so that the substance has more splendour than even the noble opal. The exquisite vivacity of the tints can only be equalled by some of the celebrated iron ores of Elba;

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* Mr. Parkinson, Org. Rem. vol. i., informs us that peacock coal is found in Somersetshire at a considerable depth, the surface being mingled with fossil shells, and vestiges of fern.

and probably, on a chemical analysis, these kinds of coal would be found to yield a small portion of iron and sulphur.

The structure of coal, as already mentioned, may be regarded as universally schistose: and it is believed that even the columnar may be considered on a large scale, in the same point of view, that is, the columns are horizontal, and piled like billets of wood on each other. The small columnar kind found in Scotland, consists of little columns, about half an inch in diameter, and a few inches in length, united in a common base *. Its form seems to arise from the ferruginous gangart, which envelopes, as in a sheath, the little columns of coal; and it is likewise said to occur in a form merely schistose. It is in fact so minute as rather to belong to lithology. The chief variations of coal can therefore only be classed as aspects.

Aspect 1. Common coal. This substance is only observable when it presents some remarkable diversities, is accompanied with singular accidents, or is brought from new regions.

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* Mr. Jameson, Dumf. 160, says it is found about four miles from New Cumnock, Ayrshire, along with graphite, which is also sometimes columnar.

Coal from Australasia.
The same from China.
The same from Cape Breton.
Ribbon coal, from Irvine, Scotland.
Peacock coal, from Wales, or Somersetshire.
Opaline coal, from Valenciennes.
Coal with calcareous spar, from Derbyshire.
With lead, from Buckinghamshire.
With foliated pyrites, and white veins of calcareous spar, from Derbyshire, &c.
With antimony, from North America.
With cinnabar, from Idria.
With copper ore, from Saxony.
With native silver, from Hessia.
With gold, from Silesia.

Aspect 2. Laminar or *Foliated.*

From Saxony and Silesia.

From the mines of Wodensbury, or Winsbury, in Staffordshire. It is commonly of inferior quality.

Aspect 3. Cannel coal. This occurs in more thick and compact layers, and the fracture is sometimes even, sometimes large and flat conchoidal.

Cannel coal, from Lancashire and Shropshire.

The same, from Gilmerton and Muirkirk, in Scotland.

Aspect 4. Columnar coal.

As the German kind belongs to anthracite, so it is probable that the Scotish is of the same description; the latter, however, presents the velvety appearance of the charcoal plates in common coal; but is so deeply impregnated with oxyd of iron, that it is partly of a brown, partly of a metallic lustre; which may not only be the cause that it does not flame, but is probably the original source of its columnar form, which iron often affects; and as the power and predominance of that metal are very great, it often manifests its presence, by inducing almost any other substance to assume its tendencies.

MODE IV. LIGNITE.

Name.

This name has been assigned, with great propriety, by Brongniart to the substance which Werner has called *brown coal*, with his usual attachment to colours, which of all denominations are the most vague and illusory. Some who prefer Greek etymons might call it *xylite*, derived, in like manner, from *wood;* but the Latin language is equally classical with the Greek, and is of general use in the definitions of natural history; so that there seems no reason for its exclusion, while on the contrary its admission affords a pleasing variety.

The account of lignite, given by Brongniart, is so complete, clear, and satisfactory, that it shall be translated with a few subjoined observations; after premising that one of his varieties, namely jet, rather belongs to lithology in every sense, as it is found in small pieces, and only applied to minute purposes of use or decoration.

The others are found in large beds or masses, by the Germans called *bergarts;* and though many rocks are composed of shells, corals, madrepores, and other animal remains, the reader might be startled at the idea of a rock composed of wood. Yet rock-salt, which will be treated among the Anomalous, perhaps affords an idea little less incongruous; and too great precision would lead to neology, which ought always to be avoided, except in cases of indispensable necessity. Rocks of pumice or of obsidian, or even of topaz, are ideas equally new to the generality of readers, yet they exist in nature, which must be followed, and not controlled.

Brongniart's account.

" The combustible minerals which belong to this species, are characterised by the odour, and the products of their combustion. The odour they spread in burning, is pungent, often fetid, and has no analogy with that of coal or bitumens. They burn with a clear flame, without bubbling or caking like coal, or running like solid bitumens. They leave powdery ashes like those of wood, but often in greater quantity, more ferruginous, and more earthy: they seem to contain a little potash *. These combustibles give an acid by distillation, which coal does not.

" Lignites vary in colour from deep and shining black, to an earthy brown: the texture of the greater part of the varieties indicates their origin, and gives rise to their name. The woody tissue is often observed, though sometimes it has wholly disappeared. The fracture of lignite is compact, often resiniform and conchoidal, or shining and straight.

" The external characters of the varieties of the species differ too much among themselves, to allow them to be farther generalised.

" 1. *Lignite jet* †. It is hard, solid, compact, and capable of receiving a very bright polish; it is opake and of a pure black; its fracture is undulated, and sometimes shining like that of

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" * M. Mojon found about 3 in 100 in the ashes of the bituminous wood of Castelnuovo.

" † Jet, Haüy.—*Pechkohle, piciform coal. Broch.*"

pitch. Its specific gravity is 1,259. It is said to be sometimes lighter than water*.

"This variety is found in layers of little thickness, in marly, schistose, calcareous, or sandy beds. The organic tissue of wood is sometimes observed in it.

"This lignite is found in France; in Provence; at Belestat, in the Pyrenees; in the department of the Aude†, near the village of Bains, six leagues to the south of Carcassone; this sometimes contains amber; and near Quilian, in the same department, in the communes of Ste. Colombe, Peyrat and Bastide; it is at the depth of 10 or 12 yards, in oblique layers, between beds of sandstone; but these layers are neither pure nor continuous. Jet, proper to be worked, is found in masses, the weight of which seldom exceeds 50 pounds. These mines have been wrought for a long time, and have produced a considerable quantity of jet, which is cut and polished in the same country.

"In Germany, near Wittemberg in Saxony; it is also there wrought and polished. Very fine jet has been found in Spain, in Galicia, and

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"* I doubt if real jet be ever lighter than water. This property seems rather to belong to the next variety."

† An account of the manufacture of jet, in the department of the Aude, may be found in the Jour. des Mines, No. 4, p. 35.—P.

in the Asturias. In short, it is mentioned as occurring in Iceland, in the western part of that isle.

"Of this combustible, ornaments are made, particularly mourning trinkets. Jet is polished with water, on a wheel of sandstone, worked horizontally. Jet, mingled with pyrites, is generally rejected.

"2. *Friable lignite**. This variety is found in extensive and thick beds; it is of a bright black, but less bright than the preceding kind; what above all distinguishes it, is its great friability; its surface is always cracked, and its masses are divided, with the greatest facility, into a number of cubic pieces, a character which lignite jet does not present. In some instances, the tissue of vegetables, which have formed it, is observable.

"Friable lignite is more abundant, and consequently more useful than the two first varieties. It is found in horizontal beds, often thick and extensive, but is never found in such large masses as coal, with which it has very improperly been confounded. It not only differs by its properties, but it also differs in its locality. It is found in masses of sand, which often fill calca-

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"* *Moorkohle, mud coal. Broch.*"

reous valleys, or which lean against the hills which skirt them. It is also found, but more rarely, in argillaceous marl.

"This combustible is common enough in the south of France, particularly in the department of Vaucluse. I have found it under the circumstances I have just mentioned, at Piolin, near Orange.

"It is found in very large mass, at Ruette, department of the Forests.

"It easily burns, but emits a very disagreeable odour. It can only be used in manufactures, and to burn lime. Smiths cannot use it in their forges.

"3. *Fibrous lignite* *. Its colour varies from a clear blackish brown to a clove brown. It has a perfect woody form and texture, consequently its longitudinal fracture is fibrous, and in its transverse fracture are perceived the annual circles of the wood.

"It is easier to break than wood; under the knife it assumes a kind of lustre.

"This lignite is sometimes found in considerable masses.

"It is found in France, in the neighbourhood of Paris, near St. Germain, in the isle of Chatou,

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" * *Gemeiner-bituminoses-holz*, common bituminous wood.—Wern."

which seems to be entirely formed of it; and near Vitry, on the banks of the Seine, there is a thick bed of trunks of trees well preserved (Gillet Laumont). In the department of Arriège, the clefts of this lignite are penetrated with sparry carbonate of lime. In Liguria, near Castel-Nuovo, at the mouth of the Magra, it is in thick and very extensive beds. In Hessia, near the mountain of Ahlberg, the layer is two yards thick. In Steinberg, near Munden in Hanover, it forms two layers, one 10 yards, and the other six, which are separated by a bed of rock from 12 to 14 inches thick. In England, at Bovey near Exeter, there are 17 thick beds, which are at a depth of about 66 feet, under sand, and in potters clay. In Iceland it is very abundant, and is called *surturbrand;* the trunks which form these heaps are very distinct, and seem merely to have been compressed.

" But this lignite is still more common in little detached masses; sometimes it accompanies the preceding varieties; sometimes it is found alone, in small layers, in the midst of beds of argil or of sand. It is met with almost every where, and is used as fuel in those places where it is abundant.

" This vegetable, rather than mineral combustible, being scarcely decomposed, would not deserve to form a variety in the systems of minerals, if it did not pass by imperceptible degrees to the varieties which precede it, and to that which follows. Its history, in strict language, more properly belonging to geology, than to mineralogy.

" *Earthy lignite* *. This substance is black, or of a blackish brown, mingled with a reddish cast. Its fracture and aspect earthy, fine grained, rather soft, even friable, smooth to the feel, and becomes bright by scraping. It is nearly as light as water. It burns, emitting a disagreeable smell.

" It not only often contains remains of vegetables, but sometimes itself presents the texture of wood, without ever possessing either the colour or brightness, or the hardness of the preceding varieties.

" Earthy lignite, burns sufficiently free to be used as fuel; it gives a gentle and equal heat, but exhales an odour generally unpleasant, but sometimes rather agreeable.

" It is found sometimes in the midst of secon-

" * *Bituminose holzerde*, earthy bituminous wood. Broch. Vulgarly earth of *Cologne*, and sometimes, but improperly *Umber*. Umber, properly so called, which comes from Italy, or the East, containing nothing that is combustible, cannot belong *to this species*".

dary earths in the neighbourhood of coal mines; sometimes, and even most often, in alluvial land.

"We shall mention, as an authentic example of this variety, the earthy lignite of the environs of Cologne, known in trade by the name of earth of Cologne, as it is wrought at a little distance from that city, near the villages of Bruhl and Liblar. This lignite forms very extensive beds of eight or ten yards in thickness, which are situated under considerable elevations. It is immediately covered with a bed, more or less thick, of rolled pebbles of quartz and jasper, as large as eggs, and reposes on a bed of white argil, of an unknown thickness. The bed of lignite is homogenous; but fossil vegetables are found in it, very well preserved. They are, 1. Trunks of trees, lying one on the other, without any order, the wood being black or reddish, generally compressed: they easily exfoliate, by drying in the open air. Some belong to trees of the dicotyledon kind, others are fragments of palm-trees. Among these, M. Coquebert-Montbret has found some which are full of small round pyritic bodies, resembling grains of small shot *. This wood

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" * M. Heim has remarked in the lignite of Kalten-nordheim, in Thuringia, small elongated spherical substances, resembling a pod of two partitions. M. Blumenbach supposes them to be unilocular bivalve capsules. (*Journal des Mines*, No. 108.)"

burns very well, and even with a kind of flame. 2. Woody fruits, the size of a nut, and which have been known to be those of a species of the palmtree *(areca)*. The lignite of Cologne contains about 0,20 of ashes, rather alcaline and ferruginous (Ant. L. Brongniart.) Its uses are various; it is worked in open air with a simple spade; but the more easily to transport it, it is wetted, and moulded in vases, which give it the form of a truncated cone.

" It is used as fuel in the environs of Cologne. It burns slowly but easily, and without flame, like tinder, giving a lively heat, and leaving very fine ashes. These ashes being considered as a very good manure, to obtain them a part of this lignite is burnt on the spot where it is wrought.

" Earth of Cologne is more especially used for painting in distemper, and even in oil colours. The Dutch use it to adulterate their snuff; when it is not mixed in too great a quantity it gives the snuff a fineness and softness, which is much esteemed, and cannot be in the least injurious. (Faujas.)

" This lignite is also said to be found in Hessia, Bohemia, Saxony, Iceland, &c. (Brochant); but as there has been a confusion between this combustible and the variety of ochre, called *umber*, we cannot be positive that these local indications have really any relation to earthy lignite.

"It may have been observed, from what has been just said on the situations peculiar to some varieties of lignites, that this fossil combustible belongs to soils of the most recent formation, since it is only found in accretions of sand or argil. It is almost never met with under rocky beds, except in coarse carbonated lime, and under basalt. In the mountain of Ringe Kuhle in Hessia, several thick layers of lignite are observed, lying on a sandstone, and separated by layers of potter's clay and sand (Mohs). On the sea shore, near Calais, fragments of lignite have been picked up, which were penetrated with crystals of quartz, very limpid, and disposed in spheres.

"Lignite then is of a very different formation from that of coal; and M. Voigt thinks that there is no transition between those two combustibles.

"The air which circulates where lignite is wrought is generally bad*."

Of Cologne.

In his Essay on Geology, Faujas has given an accurate and ingenious account of the prodigious mass of lignite near Cologne, which extends for many leagues, and is covered with a bed of pebbles from 12 to 20 feet in thickness, while the lignite itself exceeds 50 feet [*]. Our ingenious observer says that the trunks of trees, which are often found, are always deprived of their branches; whence he argues, that they have been conveyed by the ocean. Besides the nuts, which now belong to Hindostan, the Moluccas, and China, masses of a kind of gum or frankincense are found, which when burnt perfume the huts of the peasants [†].

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* Brongn. ii. 30.

Masses of a similar kind have been found in many quarters of the department of the Aisne; one of the most remarkable being that near Beaurieux, where a pit sunk to the depth of 65 feet, ended in a subterranean marsh, full of sand and water, which soon filled the pit [‡]. In that of Villers-en-Prayer, at the depth of 17 or 18 feet, a lignite was found much impregnated with pyrites, as are most others of the Aisne. In this bed of decomposed wood, which is about three feet six inches in thickness, are found pieces of fossile wood, partly carbonised; some bones of animals, seemingly of wild kine; amber in round or angular fragments, some quite transparent and sometimes imbedded in pyrites. Such venerable relics must not be confounded with peat, which commonly proceeds from the decomposition of graminous and other small vegetables, though trunks, hazel nuts, &c. be occasionally found. Faujas supposes with Patrin, that coal itself may often consist of wood brought by the sea, and deposited in recesses at considerable elevations, when the globe was studded with primeval islands. The numerous sea plants, molusks, and oily carcases of so many fish that daily perish, also contribute, in his opinion, to this product; but this theory has many difficulties.

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[*] i. 410.

[†] There is in Prussia a mine of amber, 98 feet deep, and the amber is found between two salbands of lignite, and sometimes adherent. Jour. de Phys. tome xxxix, p. 365. At Vorospatac, in Transylvania, a lignite is found with leaves of gold. Journ. des Mines, No. 23, p. 83.

[‡] In Mount Meisner, Hessia, there is a very thick bed of fossil turf, with trunks, branches, and roots of trees, reposing on limestone, and covered with basalt. De Luc, Geol. 339, thinks that such hills had sunk under water, and were again elevated. At Schemnitz there is a vein of lignite at the depth of 360 yards. Journ. des Mines, iv. 807.

Professor Hollman of Gottingen, published in 1784 an account, which had before appeared in the Philosophical Transactions, vol. 51, of some hills or mountains, as he calls them, near the city of Munden, and in that point of land which is washed at their junction by the rivers Werra and Fulda; one is about 1150 feet in height, and they may be said almost to consist of fossile wood. Another near Altendorf, on the borders of Hessia, about 1800 feet in height, presents vast quantities of fossile wood, under a stratum of stone, not less than from 80 to 140 yards in thickness *.

Bovey coal.

One of the most remarkable lignites is the Bovey coal of England, already mentioned. Dr. Kidd observes, that it is attended with a kind of porcelain clay, derived from the waste of the adjoining granite hills, subsiding into this heath, which is a natural basin †. The sandy quartz, and fragments of felspar, correspond with those of the adjacent granite. This lignite often rises in the form of trees, but is often compressed in straight flat pieces, three or four feet in length, which are called *board-coal*, from a natural resemblance; an observation which may also be extended to the *surturbrand* of Iceland. Mr. Hatchet has, with his usual acuteness and ability, examined many similar substances, as the wood of the submarine forest, off Sutton, on the coast of Lincolnshire, which he found yielded kali, and had no character of coal. An analysis of 200 grains of Bovey coal yielded water 60, thick brown oily bitumen 21, charcoal 90, mixed gaz 29.

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* Parkinson, Org. Rem. vol. i. He supposes that petrified wood passes through a bituminous fermentation, after which it is saturated with water full of siliceous particles. See also ii. 285, where he adds, that animal matter, by long residence in water, was first converted into the *adipocere* of Fourcroy, resembling spermaceti. This ingenious writer has also observed, i. 364, the presence and influence of bituminous matter in the semi-opal, and other stones of a waxy lustre; so it may enter into the opal. But as Klaproth only found inflammable matter, may not the carbon, which forms a large proportion of bitumen, here exert its power?

* Outlines, i. 166.

Origin.

The presence of the substances, called by the chemists *extract*, *resin*, and *fibre*, are esteemed to evince the original vegetable character, however it may be transmuted or disguised. The excellent experiments of Mr. Hatchet, demonstrate that the *extract* is the first principle that disappears, next the *resin*, and lastly the *fibre*. When every mark of organisation has thus disappeared, the substance becomes compact, and the conchoidal fragments resemble pitch[*]. In this new condition it is called coal, to which the lignite of Bovey nearly approximates. In the strata of this substance, Mr. Hatchet also observed small masses approaching to the nature of the lignite of Cologne, and which he called *resinasphaltum*, or resinasphalt, as it contains about 55 of resin, and 41 of asphalt.

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[*] Ib. ii. 42.

STRUCTURE I. FIBROUS.

Aspect 1. Entire. Bovey coal.

Surturbrand, from Iceland.

Fibrous lignite, from France, Liguria, &c.

Aspect 2. Mingled. Bovey coal, with resinasphalt.

Lignite, with amber, from Prussia.

STRUCTURE II. FRIABLE.

From the south of France.

STRUCTURE III. EARTHY.

Aspect 1. Entire. Umber or earth of Cologne.

Aspect 2. Mingled. The same, with nuts resembling the areca.

With a gum which burns like frankincense.

Having thus described the ESSENTIAL ROCKS, or those which receive their divisions and denominations from preponderant or from predominant substances, whence they might also be called SUBSTANTIAL; it now remains to attempt a clear classification and description of the ACCIDENTIAL, or those which must necessarily be arranged according to attendant accidents and circumstances.

END OF THE FIRST VOLUME.

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